THE GREAT MUNITION FEAT

1914–1918

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BY

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"I have known when he would have walked ten miles afoot to see a good armour."—SHAKESPEARE.

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FOREWORD

Since the war ended we have seen a reaction of sorts over the munition crusade between August 1914 and November 1918. Enthusiasm has waned: it is in human nature that it should have waned: and some people have rushed to the conclusion that it was a ruinously wasteful crusade, inefficient, even corrupt. My conclusions differ from these. I have been made well aware, whilst visiting factories, talking to their managers and workpeople, and collecting information and impressions for this book, that money was spent with both hands all through the movement; that there were mistakes, overlapping of authority, disappointments, failures, in this branch of industry and in that during the four and a half years. But viewing the thing as a whole, not suffering the judgment to be diverted by details, I have concluded that, far from being ruinously wasteful, this was the least spendthrift of any great national industrial effort in our history. We compressed into that period of peril and burning anxiety the labour and the intelligence and the public spirit which ordinarily would be expended in four decades rather than four years or so. Surveying the feat and its figures of output, I confess I cannot imagine

how we accomplished it. The difficulties immediately and menacingly confronting us were Himalayan, so that we could not see beyond them. Yet, incomprehensible, there is the fact that we did surmount them at last; saving ourselves thereby from disgrace, from becoming the "conscript appanage of some foreign Power."

The notion that the crusade was corruptive strikes me as grotesque. It wrought among us an excellent harmony which our differences during the past year have not dissipated—have only seemed to dissipate. No candid man who witnessed the work going forward in the factories and arsenals during the war, who witnessed munition makers, organisers, and inventors springing of one will to their task, always with a fresh heart whenever Germany threatened to overwhelm our hard-pressed armies, will question that. I am conscious of no exaggeration in saying that our industrial feat complemented admirably our military feat between 1914 and 1918.

It is sometimes said—though perhaps not seriously, or not by the entirely sane—that we have heard enough of the war and all to do with the war; and want, instead, the jazz now. If that were the general spirit to-day, the munition feat would appear to have been a spendthrift and vain thing. But it is not the general spirit. The nation has not the least intention of putting 1914–1918 out of its mind, all the great things that were done by its best workers at the Fronts and at the Base in those years of devotion and

sacrifice. To forget would be to go under in the ferment that naturally follows war and victory. I favour forgetting many of the vulgar, vengeful cries of the war; but its sacrifice, its skill, the vast cosmoramic drama of it—Never!

The munition feat, apart altogether from sentiment, deserves to be recalled and scanned closely, for it was full of illuminating, suggestive lessons to industry in peace-time. It threw a flood of fresh light on production, which is our chief material need to-day. It was an invaluable educative training. It showed us, by the exact subdivision and organisation of labour, unskilled and skilled, how to achieve a far larger output within a given space of time and with economised labour and resources. It applied science to industry in departments where hitherto science had been a diffident stranger, cold-shouldered if not sneered down. As soon as we can reach a reasonable working partnership between labour and capital, these lessons will be applied with great results to the industries of peace.

The munition feat was of such a stupendous nature, affecting virtually all the chief national industries, that many volumes will have to be produced to illustrate it. The official record of munitions, a huge undertaking, ought to be given to the public. I hope that we shall not have to wait very long now for the opening volumes at any rate.

One of the chief benefits of the munition crusade was the way in which it welded us together at home, so that classes hitherto widely separated coalesced

and knew good comradeship. After all, when everything has been said about quarrels and strikes between August 1914 and November 1918, it remains that there was a far more heartening "sense of human brotherhood" even here at the Base than in the four years before the war. The histories of the munition crusade which are being prepared will certainly emphasise this truth and help to keep the sense alive among us.

This book is restricted to the problem of war industry and its organisation at home. It only touches incidentally, or where unavoidable, on military matters. The use which our High Command in France made of the munitions of war, as soon as they were delivered in adequate bulk from the summer of 1916 onwards—the masterly skill by which finally, between August 8 and November 11, 1918, it broke the German Army irretrievably with these munitions—is another and a profoundly interesting subject. But its discussion would be out of place here.

CONTENTS

CHAPTER I

THE TASK OF TITAN

WHICH was mightier in the struggle of 1914–1918, Man or Machine: human will and heroic endurance on the field, or engineering and scientific ingenuity in the shop, producing that vast mass of destructive material which differentiates this war from all other wars in history? One school of opinion has pressed the claims of the latter. It was an engineers', a chemists', war! It was a race between us and the enemy in the production of guns, shells, aeroplanes, tanks, small arms, gases, high-explosives, and all manner of offensive and defensive implements for land and sea, ever increasing in quantity, in devilish ingenuity! Another school prefers to dwell on the invincibility, after all, of the Man against the Machine, on the triumph of spirit over matter. In his captivating little book, *Les Derniers Jours du Fort de Vaux*, Capitaine Bordeaux describes the start of the German artillery attack at the fight for Verdun. The woods of Consenvoye, Moirey, Hingry, Grémilly, Spincourt, and Mangiennes, the hillsides of Romagne and Mormont, lit up with the fire of the enemy's guns. An officer wounded in Caures Wood said that when, after that storm, he came into the open, the country he had known for the last four months was unrecog-

nisable. Scarcely a tree was standing, and the ground was so broken up by shells that it was difficult to move about. Communication trenches had disappeared. The main trenches were shattered; yet instantly they were manned by indomitable troops! "Elles furent aussitôt garnies!" says the author—"constatation qui place la volonté humaine au-dessus de toutes les puissances physiques déchaînées. Le haute commandement en a tiré cette formule: 'ce que l'artillerie réalise, c'est la diminution des moyens matériels de la défense et son âme morale, non pas sa destruction.'" At Vaux itself, where the power of munitions pitted against the human will first played such a gigantic part in the drama of war, and on the Somme in other scenes where they were used in still vaster quantities, I turned over this question of the Man and the Machine without being able to reach a definite conclusion as to which school of opinion was in the right. In all the great military despatches from the field, our own or any other, the man plays incomparably the greater part, is the decisive factor; and certainly he would be soulless and unimaginative who was not inspired far more by the valour and endurance of the fighter than by the mechanical skill and mass of the war material.

The truth is, that all through the war there were occasions when the munitions and mechanical side was dominant, the part it played for one side or other being the more observed and masterful, though even then, of course, owing largely to the men, gunners and others, who directed it; and there were other occasions when, munitions often having played their preparatory share in an offensive, the rest, glorious and terrible, belonged to the fighting man,

to his skill and to that "inborn warlike instinct" in which Kinglake perceived "the gift of high Heaven to chosen races of men." Roughly speaking, in land attack the rôle of the munitions was chiefly—though far from entirely—demonstrated in the tremendous artillery preparation and in the barrage which followed; that of the man, in "going over the top," and perilously, skilfully reaping the fruits of that preparation. Also, increasingly as the scientific methods developed, the man and the mechanism grew more welded together. Low-flying aeroplanes had begun for offensive purposes to work in scientifically with the infantry at the close of the war; tanks and infantry advancing virtually together, and working in harmony with each other, as in the Battle of Cambrai in November 1917 and in later engagements, won signal successes. Cambrai appears to be an apt illustration of this close partnership between the man and the munition; for though the attack, in which the preliminary artillery preparation was, for the purpose of sudden surprise, dispensed with, could not have succeeded but for a large assemblage of tanks—a munition triumph—these tanks in one noticeable instance failed to achieve much against the entrenched enemy at the edge of Bourlon Wood because there was not a sufficient infantry force there to back them up.

The more intimate the understanding, the touch, between man and munition, the more striking the success of our arms. This was illustrated more and more as the war progressed. It applied to tanks, to aeroplanes, to all the masterful engineering contrivances and scientific arms of precision used in the struggle.

The war should not be described as "an engineers' war." The term is invidious, it is inexact. The munitioner himself does not, and cannot, claim it. What he can, with reason and truth, claim is that he was the indispensable faithful comrade of the man-at-arms who fought the war and won the victory.

The need of an overwhelming mass of munitions was not borne in on the nation till the war had been fought for many months. Even in the spring of 1915, when the shell-making crusade started, the whole country by no means understood that, besides shells and guns, it needed all manner of war material in great and ever greater quantity, if its military and naval forces were to prevail. But when the truth that we were in peril grew clear, the munitioner sprang to the task with a great will, till finally he reached that extraordinary output of war material of thousands of different kinds which made light of the losses even of March and April 1918. There was the acid test! But actually after that there was no sign of a decline in his effort, and in his will-to-output; nor of a decline in the national resources and science behind him. Lord Palmerston, congratulated by a friend—John Day, his trainer at the Danebury stables—on the news of a speedy peace in 1856, expressed his thanks, but added that we were making peace just when we were preparing in right earnest to engage in war! That could not be said of the day in November 1918 when the Armistice was announced. We had started in right earnest making war on a huge scale not long after Lord Kitchener called for his millions of men. We had begun to make munitions before the munition crusade of the Spring of 1915 opened—naval munitions, for example—

at the established armament firms on a larger scale than commonly supposed; but at the time of the Armistice there was certainly no sign of a decline in our productive effort. As will appear later in this volume, we were then actually starting on new and massive projects which were in 1919 to arm more powerfully not our own forces only but those of our Allies as well. I shall never forget going through a large workshop in the North of England late in September 1918, and witnessing the making and testing by German rifle-fire of the plates of our new type of tank, Mark VIII.; thence passing on to another workshop in the same district and witnessing the production and the testing of the engine to drive this super-tank. Mark VIII. was destined never to go into action; but had the war continued, Great Britain would have assembled and despatched to the Front large numbers of that great type by the early spring of 1919. That was no isolated instance of preparation and zest for larger munition effort than we had hitherto reached. Aeroplane production was by no means at its zenith when the Armistice closed the war; we had only just taken up in earnest the project for an armoured aeroplane; and there were all sorts of other branches of munitions that were increasing, or about to increase, in November 1918. Moreover, the organisation of the Ministry of Munitions itself was then keeping pace in growth with the growth of the war material.

Had Palmerston been in charge of the war effort at the time of the Armistice of 1918, he might have said at any rate that we were then just beginning in earnest to prepare for the start of the final and greatest effort of the war.

The munition effort had its strategy and tactics, its vast co-ordinated organisation ; it had its burning anxieties and trials and its set-backs, somewhat as the Army at the Front. And to understand thoroughly how the war was fought and won by the man-at-arms, it is absolutely essential to survey this immense feat of (1) manual and machine labour ; (2) scientific research and application ; and (3) organisation at the Base. This applies to all the greater Powers on the side of the Allies—as well as to Germany, of course—but especially it is true of Great Britain, because we were compelled to produce so extensively and convey to other armies besides our own.

Moreover, the munition effort here is worth studying quite apart from its effect on the war. From May 1915 to the close of the war munition work is illumined by lessons in the industry of Great Britain from the standpoint of peace production. It throws fresh light on labour problems, hours, wages, welfare, and the hitherto unrecognised possibilities of woman's work in new fields. It shows that before the struggle we were in the twilight, or the dark, as to the nature of skilled, and semi-skilled, and unskilled grades. Then the possibilities of industrial progress through the encouragement of science, notably the science of the chemist, are vividly illustrated by the munition effort in those four years 1915–1918. Finally, engineering skill and knowledge received a great impetus during the period. Through pressure of work, the urgent need to save time so as to enable one hand to accomplish what two hands would at ordinary times be employed on, and conversion or the constant and swift changes from one class of output to another, the engineering intelligence was incessantly stimu-

lated. As a result, all manner of fresh devices, labour- and time-saving, were thought out and applied in the machine and machine-tool departments. It is scarcely too much to say that in 1915 British engineering was sent again to school, to come out at the close of the war a far more accomplished scholar in various departments than it had ever been before. The production of war material has always been regarded as unproductive by the political economist. No one need dispute that. But it is none the less true that during the British munition effort engineering as well as chemical discoveries and improvements were made which must add largely to the wealth of the country when they are applied to peace production. It was impossible to go through the factories and workshops of the North and the Midlands in 1917 and 1918, as I did, without being struck by this progress in ingenuity and application.

The task confronting the country when called on to equip not an Expeditionary Force, a mere military adventure within strictly defined limits, but an army of millions of men on the scale of the great conscript Powers, was titanic. Nothing remotely of its nature had ever before been put suddenly on a nation. We were in for an adventure, utterly unforeseen, in the course of which we were going to produce 258,400,000 shells; 3,954,000 rifles; 240,000 machine guns; 25,031 field guns and heavy guns and howitzers[1]—and that was only one side to our output of war! What, in regard to a possible or probable conflict with Germany, was our war programme from 1906 to the outbreak of hostilities in August 1914? I do not propose here to discuss the question of what

[1] But see page 108, lines 21-22.

ought to have been our programme, or of what France ought to have asked us to do in 1906, or in 1911 when over the Agadir crisis the probability of war greatly increased. That is wholly outside the scope of a work on our munition effort. But, to understand the task so soon as we resolved in 1914 to create an army on a Continental Power's scale, it is necessary to have a clear idea of what Great Britain was expected, and agreed and meant, to do. Great Britain did not intend to raise a large force by conscription. Lord Roberts and others pressed for obligatory service for home defence more or less on the lines of the scheme adopted by Australia. But even this was not regarded as "practical politics," and one may add that, had this been adopted, it would not at all have implied a huge munition-making effort. The far more ambitious scheme, which Great Britain ultimately adopted, conscription outright and an army on the Continental scale, was simply not considered. It was not dreamt about. No statesman and no party suggested such a thing. The arrangement or understanding between Great Britain and France from 1906 to August 1914 was this: if Germany made an unprovoked attack, we were to stand in and aid France with (1) our Navy; and (2) an Expeditionary Force. France asked for 100,000 men, considering that, with the aid of that force, she would be able to withstand in time an attack by Germany. To that number we decided to add another 60,000 men; and the agreement was that the force should be ready within twelve days.

The Territorial scheme was a later step, and had nothing to do with our understanding with France. The Expeditionary Force at the time war broke out

was, for its size, quite well equipped. I have heard the evidence on both sides. One side declares that it was ill, even wretchedly equipped; the other side would insist it was a model. I cannot agree with either. But, on the whole, I think the first side is the less accurate. It talks and writes in the light of 1915 chiefly, which is quite another matter than the equipment of the Expeditionary Force before the war. Our supply of aeroplanes no doubt seems ludicrously small when compared with later figures. The total was only 179, and the number of new machines for the R.A.F., which included both Army and Navy, constructed in the first nine months of 1918 was between twenty-six and twenty-seven thousand! But it must be borne in mind that the aeroplane was essentially a development of the war; the German and French aeroplane figures leaping up in the same way as our own as the struggle progressed. Nor was the Army furnished with any substantial reserve of optical instruments of precision; so that owing to our dependence on Germany for sixty per cent of the glass used for such instruments, we were dangerously short of this form of munitions till a new home industry for them was started in 1915. Much the same applies to magnetos; we seem to have forgotten all about them, preferring to remember horses, instead, for transport purposes.

As to rifles, in which we specialised, the Expeditionary Force had a good weapon, though perhaps not so good as the weapon planned in 1911 when war had threatened; but this latter rifle was not adopted; I believe that, in regard to one thing, there was a difficulty, not surmounted, over the cartridge case. We had a good 18-pounder field-gun, which

stood the test of war well, though it was greatly improved before the close. With this, and its 13-pounder and 60-pounder guns and its 4·5″ howitzers, the Expeditionary Force was—for an Expeditionary Force—creditably armed. It had—bearing always in mind the limited and modest character of its engagements—a sufficiency of shrapnel shell for warfare of manœuvre and movement, and a reasonable reserve of this shell. The reserves were based on the report of the Interdepartmental Committee presided over by Sir F. Mowatt, at the time of the Boer War, which recommended a 25 per cent reserve of field-guns, and also of machine-guns. As to the last named, a Machine-Gun Corps did not of course exist even in the imagination in those modest days. We specialised in the rifle and its marksmanship, which was one of our strong points—and a really strong one. Two machine-guns per Battalion, or twenty-four per Division, was the scale for an expeditionary force. But that was the fault not of the Army chiefs. It was the foible, rather, of strict economy. High-explosive shell for field-guns, or enough for other guns in siege or trench war on a large scale, we lacked, though we need not quite forget we had some lyddite, which is high-explosive, contrary to a vague prevailing notion that only T.N.T. is that! The opinion of the British authorities favoured the shrapnel shell as against the high-explosive before the outbreak of the war, and until it was seen, after the brief phase of manœuvre and movement, that the latter was absolutely essential for destroying trenches and earthworks of the enemy. The Germans believed in high-explosive. They possessed it in large quantities. The French Army was also supplied with schneiderite; but

it is not at all clear that either of these nations provided it in case of a long trench war. British military opinion overwhelmingly believed in the superiority of shrapnel for field artillery; and presumably it would be argued that a small force of 160,000 men was fashioned for that purpose, in case we were called on to fulfil our pledge to France. But, in the light of what happened directly the enemy retired to their Aisne positions a few weeks after the start of the war, it is impossible not to regard the omission of high-explosive shells for field artillery as a defect. We had of course a certain amount of high-explosive —lyddite, for we had not yet exchanged this for trinitrotoluene admixtures like Germany and France. But it was utterly insufficient for our purpose when the enemy went to earth.

Whilst our Army was still nothing but an expeditionary force, it was severely handicapped by its pressing need, at the Battle of the Aisne, of high-explosive: and what shells it had were only for its howitzers and heavies. France had this shell, Germany also, for field-guns as well as heavy guns and howitzers. The fact that we needed it cannot be overlooked. It was the chief flaw in the otherwise creditable equipment of our small force. The defect was perceived as soon as we attacked on the Aisne, and plans were put forward for correcting it; but then neither the material nor the means for producing this shell in large quantities were ready. High-explosive, even if you have it in plenty, cannot be gaily packed into 18-pounder and other shells not intended for it. Lord French, in the chapter on "Ammunition" in his book "*1914*," lays great stress on the importance of high-explosive shell not only for the heavy guns

and howitzers but also for 18- and 13-pounders. He pressed for supplies of it as early as September 28, 1914, and on December 31, 1914, he furnished a table stating the required amount of it for his eight different kinds of light and heavy guns, and howitzers.[1] In May 1915 he strongly reiterated his urgent requirements of high-explosive shell after he had witnessed the failure of his attacks at Festubert, made in order to relieve the pressure on Ypres. But unfortunately the high-explosive in adequate quantity was not forthcoming, and he was instructed to economise. But did the facilities and the organisation for speedily producing enough of this particular shell—or indeed of the ammunition generally and of the guns so terribly needed from September 1914 onwards—then exist? Could Lord Kitchener have supplied the required amount in 1914 and 1915? Obviously he could not. The necessary organisation simply did not exist during those months. Therefore we suffered. *It takes the best part of a year to produce shell on a manufacturing scale when you have to start from the very beginning:* that is one of the lessons of the whole munition effort 1914–1918 which have been forced home on us.

To revert to the position before August 1914. The difficulty the military authorities had before the war in getting money freely for their requirements was continuous and discouraging. The prevailing spirit was expressed in the words of Mr. Arnold Forster ten years before the war—"The cost of the Army will be greatly reduced." Parliament before

[1] But the first proposal to use H.E. shells for field-guns came from the War Office at the start of the war. A small consignment was sent to France in October 1914.

August 1914 would only sanction enough money for the one cavalry and six infantry divisions which composed the Expeditionary Force. The Treasury rules were rigid. But had the General Staff believed in and asked for a supply of high-explosive as well as shrapnel shell for field artillery, it would no doubt have been granted. Lord French in his work states that he had always been a strong advocate for the supply of high-explosive shell to horse and field artillery, but got very little support, and that little lukewarm. It is obvious that the general feeling before the war was not in favour of high-explosive for these guns.

Returning to the munition-making task before the country directly it was decided that we were to turn the Expeditionary Force into an Army at least ten times as large: what were our facilities fit to start at once on equipping the new Army? We had the three Government factories: Woolwich, which in August 1914 was employing 10,866 hands (two years later the number was more than six times larger); Enfield, for rifles; Waltham Abbey, the Royal gunpowder factory.

We had the regular armament firms, such as Vickers, Armstrong Whitworth, Birmingham Small Arms, Coventry Ordnance Works, Beardmore, Firths, Hadfields, and Cammell Laird.

Various figures, official and unofficial, were set forth during the war as to the total number of workers engaged at different periods on munitions and on allied or kindred occupations for the State. The truth is it is very difficult to determine the actual number, even in round figures. For one thing, there seems no exact definition of what constituted muni-

tions. In July, August, and September 1918, the number of workers employed was probably the maximum for the whole period of the war. During this third quarter of 1918 I should say that the number of men and women working on munitions was, in round figures, about 2,871,000, the women numbering 825,000. These figures are smaller than the totals often quoted. But it should be borne in mind that they stand for munitions in a narrower sense than the one which was commonly used. They relate to the metal and chemical industries. Munitions in the broader sense embraced workers in the coal mines, as well as those employed in, for instance, the manufacture of boots, uniforms, bedding. Indirectly even those concerned in special tramway work on behalf of munition workers might be described as munition workers ; also those concerned in building and repairing factories for the manufacture of munitions.

If we add those indirect munition hands, the total suggested above would of course be much larger. I believe the total may then be put at 3,400,000, both sexes.

Before everything, at the start of the war, had to come the Navy, our first line of defence. The Armament Firms were largely absorbed in making munitions for the Navy. We could not, without courting disaster, order them to reduce their naval output, and make instead the guns, shells, and other munitions which would be needed in a short time for the New Armies, and indeed almost immediately for the Expeditionary Force in the huge conflict into which it was now plunged.

But, more than this, all previous experience

proved munition-making to be a slow process. Agreeing on the best form of munitions, realising that they will be required in great quantities, and ordering them accordingly—that is one thing. Getting these goods delivered in time—that is another. I come to the writing of this book a whole-hearted admirer of what was achieved by the great State Department which set to work in June 1915 to equip the new Army. After witnessing on various occasions at the Front in 1916 and 1917 the result of its methods, and visiting factories of all kinds at the Base in 1917 and 1918, one realised something of the magnitude of the effort. It had to compress into three and a half years of tremendous anxiety and stress a work which the military and industrial science and organisation of Germany had spread over more than a generation. It was a triumph of swift co-ordination in output and invention at the Base which was quite unparalleled in war. It would, however, be not only unfair, it would be unintelligent, to affect that nothing of note was attempted and nothing done before the Ministry of Munitions of War started in 1915. We could not have won or held our own in the struggle except for some such special and new department of State. It developed and co-ordinated the munition-making power and zeal of the nation into one great working whole: catering in certain things for Navy as well as Army, and in no small degree for our Allies as well as ourselves. But the new organisation first had to lay its plans, build its factories, assemble its army of labour and mass of material. It could not suddenly conjure a vast output of guns, ammunition, etc., into existence. It would be imbecile to represent that some magician in munitions waved his wand,

and behold the guns, and shells, and aeroplanes! There was no magician and no wand to wave. We had to make shift, as a fact, through 1915 mainly with what munitions had already been arranged for. It would be foolish and grossly unjust to overlook, for instance, the fact that the munitions accumulated for the Battle of Loos in September 1915—a small thing with what was to come, still we used more material there than in the whole of one of our former small wars—had been ordered by the War Office before May 1915; and that it was not until the spring of the following year that the first great results of the new organisation began to be apparent. Before then the bulk of its beneficent influence must be termed quickening rather than creative. The imagination that pictures the Ministry of Munitions waving its wand in June or July 1915 and creating shells in unbuilt factories is uninformed.

The truth about the organisation, the Department of the Master-General of the Ordnance at the War Office in the first ten months of war, is this: it strove honestly to get equipment adequate to the requirements of a great army in the making, but it had nothing like the necessary powers and organisation to do so.

It could not cope successfully with the tremendous vital question of labour. As a fact, we did not dispose of that in 1915, or even in 1916.

It had not really the necessary powers in regard to non-armament factories, the ordinary industrial factories and workshops throughout the kingdom which had to be enlisted for State work before we could secure enough shells and guns and other munitions, military and naval.

It was horribly handicapped by the withdrawal

of skilled workers by the haphazard and excited voluntary recruiting movement which induced highly skilled men in the engineering and chemical trades to join the fighting forces, and insulted them if they hesitated. Dr. Addison, Minister of Munitions, said in his speech in the House of Commons, June 28, 1917, that by May 1917 forty thousand of these men had been brought back to the workshops! Later on, as dilution was deftly accomplished and women and half-skilled men were able to fill the places of skilled workers, men could safely be drawn from the factories and added to the Army. Mr. Churchill, in his munitions statement, March 27, 1918, said that sixty to seventy thousand skilled men had been diverted during the previous six months to the Army, yet output still grew. But by then we were working scientifically.

The department of the Master-General of the Ordnance was also handicapped by the fact that, almost on the eve of the outbreak of war, the staffs of armament factories had been reduced.

Finally, it was not "energised" by any fervent munition-making crusade, such as the impetuous one undertaken by Mr. Lloyd George in May-June 1915, which seized the attention of the nation.

True, attempts were made when munition-making started in earnest to check the flow of skilled men out of the factories into the fighting forces. Thus in various cases where Birmingham firms had Government orders for munitions the men employed in such work were forbidden to enlist and were supplied with badges of exemption; and doubtless, if one were to go into the history of the equipment of the National Factories at Leeds, Dundee, and elsewhere in the spring

and early summer of 1915, one would find instances of firms indignantly protesting against the seizure of their workers by the recruiting fever and demanding their prompt return, sometimes even successfully. But the numbers of skilled hands that joined in 1914–1915 must have been very large. It was computed that, taking skilled and unskilled, 384,000 men joined out of a total of 1,600,000 employed in engineering and chemical trades ; but I do not know the precise date of this statement or whether the estimate is exact.

Let us glance here at some of the early difficulties, examining them in detail later.

First, and I should say most formidable, was the labour difficulty. Directly the attempt was made to increase the output of ammunition and guns in the autumn of 1914 this dearth of skilled labour was discovered. I must re-emphasise this important point. It was due to the fact that through the recruiting movement at the start of the war a large number of engineers, skilled workers, unwisely incited, had joined the colours. Endeavours were made through the first year of the war to bring back these volunteers and put them on munition work, but though a good deal was done in 1915 to effect this, the search was hard and by no means always successful. The men who had enlisted at the urgent call for men for the new Armies were often unwilling to return to munition factories and did not respond to the search. That was the spirit of the true voluntary impulse at the start ; not helpful to the munition task, yet very creditable to those 1914 volunteers. Frankly, one admires the recruited far more than the recruiter.

A much more serious difficulty, however, and a most

lasting one, related to labour generally, its restrictions and trade union rules and customs, written and unwritten. A great deal was said and written about this labour difficulty early in 1915 and onwards. Censure, public and private, was freely indulged in, though when we come to look into the matter we find that largely it was uninformed and unjust. The truth is, labour did not sufficiently understand the military position and the peril of the country; how could it be expected to understand when one of the insistent cries of the time, which other classes than munition workers were uttering, was "Business as Usual"? We must remember, too, that, till the early summer of 1915, no regular pressure had been brought to bear on employers outside armament factories; that they had not been much diverted by the State from their ordinary peace-time output to that of war.

During the first ten months of the war we were struggling to get sufficient munitions despite the fact that neither labour nor capital, neither employer nor employed, was organised on a great national basis. The task might well have been impossible in the absence of such an organisation even had the two sides been on terms of mutual trust at the start of the war. But they were not. The two sides had been in bitter conflict for a long period before August 1914, and the outbreak of war did not bring them into accord beyond a certain point. As a result, the orders for ammunition and guns, which were given when it was resolved to raise great armies, were retarded. Trade union restrictions stood in the way of the promptest delivery of the goods.

The nature of these restrictions must be considered later. Here it is only necessary to say that some of

the most important of them were acknowledged rights of one side, just as management of the works and various disciplinary rules and profits were acknowledged rights of the other side. It is prejudice or passion to assert that either the employed or the employers were unpatriotic in the opening stage of the war. There was abundant patriotism on both sides; and more and more as the demand for munitions came to be understood by the nation there was a keen desire to meet it. But it could not be anything like fully met, for capital and labour were not an organised working whole. When for the purpose of the war they subsequently became so, nothing could stop the tremendous resistless flow of munitions. Quarrels and strikes could not stop the momentum, scarcely could perceptibly check it; and we actually ended by producing more ammunition and arms than we could utilise for ourselves.

Such was the fruit of a thought-out, scientific organisation, compact of employers and employed and the State—"a tripartite treaty" between employers, employed, and the State, as Lord Curzon of Kedleston described it during a debate on the Munitions of War Bill in the House of Lords on July 2, 1915.

The more one looks into that organisation in detail and surveys it as a whole, comparing it with the welter of the first ten months of effort, the stronger becomes the conviction that the munition feat could not have been carried out on the old lines. No one State department cumbered with other great cares could have fused together the parts of the munition effort in time for the strain of 1916–1918—and the War Office was cumbered with mighty cares besides

munitions. It needed something fresh and, from a decorous official standpoint, something irregular.[1] It needed a great adventure. A good deal of badinage was provoked by the expression "push and go" used of the organisation which near the end of the first year of war took over munitions; and the expression certainly lent itself to some irony, "push" perhaps at times in the early stages standing in the way of "go." But the adventure was justified by the time the British Armies were able to strike their first great offensive blow in 1916. It was justified in the preliminary work on the Somme in which on a fourteen-mile front seventeen hundred guns were able to expend some fifty thousand tons of ammunition—chiefly the long-debated high-explosive. The quality of the ammunition was capable of improvement certainly—"prematures" were costly during this great battle—and the bulk of it and the number of guns were almost to be doubled in less than a year when the Battle of Arras and Vimy was entered on. However, at length, after nearly two years of war, we had ammunition "approximately adequate to the conduct of major operations,"[2] though even then its expenditure required careful watching.

That preliminary artillery work on the Somme proved past all serious dispute the success of the new organisation. We could not have prevailed against

[1] Also it wanted a spirit of "damn the consequences" in regard to considerations of expense, which officials brought up to dread the censure of those who keep an eagle eye on the Estimates could not be expected to show. The Minister of Munitions, happily, thrust aside all cheese-paring arguments. On one occasion at a council of Government and Army Chiefs it was decided to order at once a large number of 6″ guns. "You had better have fifty more," remarked the Minister without any one asking for them—"you'll want them." The officials could hardly believe their ears. When had anything like that been heard before from a great Cabinet Minister?

[2] Sir Douglas Haig's Last Despatch, April 10, 1919.

the war industry of Germany except by a wrench away from settled habits, and "a dead-lift spasm" of all our munition-making energies in a novel manner. The extraordinary thing is that we were able to do it in time, for modern arms of precision, where it is necessary to start from the beginning, cannot be made "while you wait." Isolated parts of them can be manufactured and delivered within a very short time after the order has been given, but not so the finished weapon or projectile. The rifle has often been cited as an illustration of this: it requires, in the making, over a thousand different machines and fifteen hundred different operations; and, starting from the beginning, includes the production of these machines.

A concrete example of the time taken ordinarily in the delivery of certain forms of munitions may be given here. Suppose an order had been made in July 1914 for, say, two hundred machine guns and two thousand rifles a week; then the first deliveries might reasonably have been expected by about the beginning of January 1916, but full delivery not before July 1916—two years after placing the contract! That would, at any rate, have been a not unusual experience in peace-time. It serves to illustrate the tremendous difficulty confronting those who in 1914 and 1915 were suddenly expected to produce munitions speedily for the New Armies, in the welter then existing, with the drain on available skilled hands, and with labour and its directors not yet fused together for war purposes. New factories—though we are apt to forget it—really were determined on, and large extensions of existing ones, during the first ten months of war.

But (1) the factories had to be built.

(2) The new machine tools had to be made and set up.

(3) The material had to be assembled.

(4) The labour had to be brought on the scene and instructed.

All this before the munitions themselves could be started on! Truly the task of Titan was set us in 1914–15.

Those who expected the War Office to deliver the goods working under the old system and in the midst of the labour and industrial chaos of 1914–15 expected a miracle in munitions.

CHAPTER II

GETTING TO WORK

THE character of the fighting, after the first few weeks of open warfare and manœuvring for position, surprised the strategists of all the nations ; we must emphasise this always whilst considering munition programmes. In writing this book I have come in touch with many people of authority in munition and military matters. None of them has suggested he foresaw the stupendous demand of both sides for munitions. Some military men here, as well as the Germans, foresaw the need for abundant high-explosive. That is another matter. Many foresaw it must be a long and mighty struggle ; still more foresaw the war years before it came—some millions perhaps make that claim ! But there again is quite another matter. The extraordinary amount of munitions to be required, together with their character, no one foresaw before the war—if indeed till the Battle of the Aisne. The chiefs of the German Army, despite the superiority over their opponents in guns and ammunition which they started with, were in some degree out of their reckoning in this ; how otherwise may we account for the marked deterioration in quality of their shells for a time at least after the heavy expenditure in

the first few months of fighting? Surely that pointed to hastier output under heavy unexpected strain?

A prevalent idea of what the war at first might be was somewhat this: an opening phase of manœuvring for position lasting for some weeks or months; then a pitched battle lasting two or three weeks, with a great expenditure of ammunition as at Mukden. After that, a retreat by the Army discomfited, a pause from intense fighting, followed by a reconstruction of its forces, and a renewed grapple. Instead, what actually happened was two months or more of an almost continuous artillery duel, in some parts of the front, between heavy guns.

Early in the autumn 1914 the British like the French Armies were awake to this feature of the struggle. Lord French has told us how speedily the Germans acted on it; especially, how the Germans leaped to the urgent need of heavy guns; and how, to rush these into action at the earliest opportunity, they even refrained from improving their ordinary field-gun. The French Government also grasped time by the forelock. In October 1914 they mobilised labour at the Base. Thanks largely to their prompt organising steps in the autumn of 1914, the French were to produce, before the close of the war, a third of a million shells a day, and in one year between ten and eleven thousand 75-mm. guns. In dwelling on our own feat, we must remember that the French were munitioners too. True, the task of the French was in one way much simpler than the British. They started as a great military nation; and they started with conscription, which simplified their labour problem. Moreover, as to shells, they were

already using high-explosive on a large scale.[1] We were not; and "it makes a vast difference to change the actual character of your armament in the midst of a war and begin afresh" (Mr. Lloyd George, House of Commons, April 20, 1915).[2] We were slower than France, less decided as to the best method of increasing output, when the revelation of this extraordinary expenditure of ammunition came to us. It serves no good purpose to deny this, provided we bear in mind (1) that though our ultimate manufacturing resources were greater than those of France,[3] our difficulties as to labour, etc., were more formidable; and (2) that, actually, in the autumn and winter, 1914–15, a great step was *attempted* towards making good our deficiencies. The latter fact has been absurdly overlooked by many critics. We should certainly have done greater things by a clear and unified control of the munition industry, applied swiftly as in France. But, all the same, we were distinctly moving between the autumn 1914 and the spring 1915. The originator of the shell and gun crusade in 1915 would be the last to deny this. He himself was intimately associated with and striving keenly in the earlier munition

[1] Though apparently they had believed that the war, when it came, would be a short one, and that the existing supply of high-explosive would suffice. Yet before the close they were producing 1400 tons of it a day. That was virtually a new industry, as a well-informed *Times* correspondent stated (Sept. 6, 1919).

[2] Among the firms which started in 1914 on making H.E. shell for Army needs were Hadfields at their Hecla Works, Sheffield. They had first to install a new series of specialised plant for the purpose. On October 30, 1914, they began to install plant for 4·5″ H.E.; the first delivery of the shell was April 3, 1915. Plant for 18-pounder started, November 27, 1914; first delivery, May 24, 1915. Plant for 9·2″, October 30, 1914; first delivery, November 25, 1914. The exceptional speed in delivery in the third instance was because Hadfields were able to use for the purpose one of their shops previously kept for commercial work which was promptly displaced in favour of shell.

[3] On the other hand, the French arsenals were greater than ours, and consequently their special equipment was superior.

period. In his speech of April 20, 1915, he gave these figures: in September 1914 our output in artillery munitions was 20 per cent above that of August, in October 90 per cent, in December 156 per cent, in January 1915, 186 per cent, in February 256 per cent, in March 388 per cent. During the fortnight's fighting at and around Neuve Chapelle in March 1915 our expenditure of ammunition was about equal to that of the whole Boer War, 1899–1903; though this amount was small contrasted with the expenditure on offensives in 1916.

These figures explain how we were able to attack at all at Neuve Chapelle and elsewhere—and how we existed, precariously, through 1915. The output was quite insufficient for our various campaigns in that year, but it really does prove there was energy. The position was depicted too rosily by statesmen early in 1915. Mr. Lloyd George himself depicted it so. It had to be presented in another shade when the great want of shells, guns, machine-guns, and trench warfare devices for the British Army in France was divulged in May 1915. All the same, output had *not* stood still in the autumn and winter.

What steps were taken in this country in the autumn of 1914? A Government committee examined the problem how to increase output, and concluded it would be best to extend sub-contracting at first among non-munition firms. The more difficult and highly technical work of assembling and putting together the various parts of the munitions was left to the Armament Firms proper. Between 2500 and 3000 other firms were thus brought into munition work by either direct contracts or sub-contracts, and

it was hoped that the parts entrusted them would be produced speedily.[1] But in December 1914 it was found that the supply remained inadequate to the Army's demands, and that contracts were not delivered within the specified time. For one thing, the scarcity of skilled labour through unscientific recruiting was, as we have seen, retarding output. The armament firms had many serious gaps through this, and their task was the more difficult because they were lending men to instruct the inexperienced workers in the new firms working on munitions for the nation. An attempt was made, by the Board of Trade working through the Labour Exchanges, to find men in industry at large to fill the vacant places in the armament firms. It failed. The difficulty continued, and on March 23, 1915, the Government passed the Defence of the Realm regulation—additions were made to it in July 1915—which empowered the War Office and Admiralty to take possession of any factory, or of its plant, and use it as they deemed necessary. They could require such munition work to be done as they thought fit in such a factory, and the occupier and servants must obey all their restrictions and directions.[2]

[1] How many firms, controlled and others, were there engaged in munitions towards the close of the war? The number 30,000 has been often stated. I suggest this meant 30,000 addresses of all sorts and kinds of people who could undertake anything. The difficulty in this matter is to say exactly what "a firm" means, to get a satisfactory unit. But I suggest there were, at the period of greatest activity, between 8000 and 9000 firms on munitions. One figure given me is 8760.

[2] The original Defence of the Realm Act of November 27, 1914, covered the ground, if less exactly, with a provision making it lawful for Admiralty or Army Council (*a*) "to require that there shall be placed at their disposal the whole or any part of the output of any factory or workshop in which arms, ammunition, or warlike stores or equipment, or any articles required for the production thereof are manufactured; and (*b*) to take possession of and use for the purpose of His Majesty's naval or military service any such factory or workshop or any plant thereof."

What may be described as the era of committeedom came into full blast after these powers had been given. "Set up a Committee" was the cure for every new difficulty as it arose. There was the Treasury Committee appointed on April 8, and originally consisting of the Chancellor of the Exchequer (Chairman), with Mr. A. J. Balfour, Mr. E. S. Montagu, Mr. G. M. Booth, Major-General Sir Stanley von Donop, Mr. Harold Baker, Sir Frederick Black, Admiral Tudor, Mr. A. Henderson. Sir H. Llewellyn Smith was co-opted at the first meeting, April 12. This Committee was concerned with matters of policy. It could give decisions on the authority of the Cabinet, but had no executive machinery. Then there was the Armaments Output Committee, which first sat on May 31, 1915. It consisted of Lord Kitchener, Mr. G. M. Booth—the man "of push and go" in the famous phrase of the Chancellor of the Exchequer—Major-General Sir Stanley von Donop, Sir Herbert Walker, and Mr. Alan Smith. Its duties were to seek means for increasing the supply of labour for the regular munition firms and the new firms which had come and were coming in, and to spread contracts outside the armament group.

There was a Committee on Production which, started as an advisory body only, grew to be of great importance later, when, under the Munitions of War Act, it exercised authority in wage and bonus questions and changes throughout the controlled factories. There were growing up, too, at this period a number of local committees connected with the central bodies. The North-East Armaments Output Committee at Newcastle was one of these, organised

by the main committee on output in London. There was a similar authority for Clydeside and for many other districts. Perhaps few people to-day have a clear conception what were the precise provinces and powers of all these bodies of advisers, travellers, organisers; what relation they bore to one onother, and how they were linked up. To-day they appear as distant figures seen through a glass darkly; though it would not be fair to apply to them the lines from *The Triumph of Life*:

> All, hastening onward, yet none seemed to know
> Whither he went, or whence he came, or why
> He made one of the multitude . . .

It seems that occasionally a body was created for one purpose, but soon evolved for quite another. It would not be ungenerous to the exertions of leading munition organisers and inspirers of this period to say that the movement was—to put it mildly—somewhat amorphous.

During this period munitions were growing, as we have seen—but the Army was growing too. It was no longer a case of providing for the brave adventure of a little expeditionary force. We had already to find munitions for five or six times as many men as landed in France in August 1914. Moreover, even at this early stage we were striving to bring some munition aid to hard-pressed Allies. Doubts were beginning to be felt as to the efficiency of the committee method. It is impossible to escape the method under our system of government; but, as the call for more munitions grew insistent, the idea spread that all these inquiring and perambulatory and advisory bodies might be overlapping, or that

there might be gaps between them, and want of co-ordination. It was obvious that some of their activities had not been fruitful. This idea found expression in a debate in the House of Commons on April 21, 1915, when Mr. W. A. S. Hewins brought forward a motion for a unified administration in direct touch with all firms capable of producing munitions and of co-operating closely. He declared that many firms anxious to produce had not yet been utilised.

In his reply Mr. Lloyd George sketched out the action of several of the committees, warmly praised the "marvellous work" of Lord Kitchener, and indicated the magnitude of the task by figures showing the growth of the Army, which was being "fully equipped and now supplied with adequate munitions."

The tenor of this speech is not easy to reconcile with what followed in May 1915. But one must remember that not to lay great stress on the peril of shortage in munitions was in those alarming weeks a powerful motive.

To emphasise the immediate need of guns and ammunition might be a heartening invitation to the enemy to strike his hardest at once ; not to emphasise it was to fail to arouse the nation to that need. We were offered the painful horns of a dilemma.

Mr. Hewins's plea for a unified administration, and at the close of the debate Mr. Bonar Law's approval of the way in which France had set about solving her munition problem, suggested one distinct body for the task. Mr. Lloyd George did not himself foreshadow it in this discussion on April 21, but the thing was taking form. The Ministry of Munitions

was really in a state of gestation weeks before its birth; if not since the late autumn 1914, at least by the spring 1915. The sharpening up of the Defence of the Realm munition clauses in March, when read in the light of the shell disclosures in May, leaves us in no doubt about this.

On May 14 Colonel Repington, the military correspondent of the *Times*, on the strength of information at G.H.Q. in France, stated that the British attacks in the district of Fromelles and Richebourg during the offensive at Festubert had failed because we had not enough high-explosive to dislodge the enemy in his strong points; whereas the French in their attacks were first levelling his parapets by a heavy bombardment. The defective supply of H.E. shell was "a fatal bar to our success." The agitation by the *Times* and *Daily Mail* ensued and brought things to a sudden head. In the House of Lords on May 18 Lord Kitchener admitted that there had been "considerable delay in producing the material we at an early stage of the war foresaw would be required." He attributed the delay to "the unprecedented and almost unlimited calls . . . on the resources of the manufacturers of the country." As to high-explosive shells for field-guns, he said we had taken early in the war steps to manufacture them, and it was confidently expected they would soon be forthcoming.[1]

[1] Speaking on June 3, 1919, on the munition question, Mr. Asquith said: "Do not let it be supposed that the Government at this time and in the succeeding months were satisfied or anything but disquieted by the munitions situation. The contractors had promised more than they could perform; they were terribly behind in their deliveries, particularly in the matter of high-explosives. The Army ought to have received by May 15, according to contract, 481,000 high-explosive 18-pounder shells. Instead of that, only 52,000, or very little more than one-tenth of the whole, were delivered."

The agitation in the Press was bitterly resented, a storm of personalities swept over platform and Press; but the obvious fact that the *Times* was directly inspired by the High Command in the field made the agitation irresistible. If the *Times* were wrong in facts, the only conclusion was that the Commander-in-Chief of the British Army in France was equally wrong; and if the Commander-in-Chief did not know about the state of our munitions there, who could? But we now see, beyond doubt, that the *Times* was right in the facts; also that publicity, vehement publicity even, was the one sure, swift way to concentrate the nation on its tremendous task.

The revelation was followed by a reconstruction of the Government, announced on May 20, completed five days later, and by the decision to create a Ministry of Munitions. At last, after ten months of earnest but distracted energy by committees, munitions for the Army were to be put under a single definite central control. The agitation had flamed over shells and guns only. Nothing was said even about machine-guns, in which the Army was notoriously deficient. But in truth a new unified authority and a convincing crusade throughout the country to plant such an authority firmly on its feet were necessary for all manner of munitions besides shells, guns, machine-guns, rifles. The New Armies were already needing various indispensable munitions which the nation had heard nothing of, and unless these were soon produced in far larger quantities both Army and Navy too would be in dire straits.

The munition manufacturers generally were in grave difficulties over gauges, moreover, without which

the munitions could not be produced in the new factories crowding in to the work.

We had to form our plans for the campaigning of 1916, of 1917. It was high time to rush the central co-ordinating authority into existence, and to advertise it by a whirlwind campaign through the chief industrial districts. On June 3 the new Minister of Munitions, Mr. Lloyd George, took the field, and plunged into his crusade in the North and West of England.

Viewing the thing critically from different standpoints; giving full credit to the men who had been faithfully striving from the outset of the war to provide munitions; not forgetting that a formidable strike in South Wales broke out not long after the crusade was over—one must still concede that this was a great stroke. It was the *tour de force* which the Army and the whole nation needed. The crusade did not create the guns and shells of 1915. Nothing of the sort. That is one of the superstitions which follow in the wake of crusades. But, in the absence here of an adamantine system for war needs such as France and Germany possessed, the shell and gun crusade was invaluable. It shocked the country to attention. The Minister, accompanied by Sir Percy Girouard and Sir Frederick Donaldson, head of Woolwich Arsenal, started at Manchester where he addressed a meeting of engineers. He laid stress on the need to increase the mobility of labour, and subordinate it to the direction and control of the State; and, as regards compulsory powers over employers, he said the rule must be "Government work first." He urged Lancashire to organise itself at once in the most suitable forms of committees for

munition purposes. After the meeting, representatives of masters and men met Sir Percy Girouard and discussed with him the best way to proceed. They agreed to form committees for the county on the model of the munitions committee already existing at Newcastle-on-Tyne; and it was estimated that Lancashire, once organised, could produce a quarter of a million high-explosive shells a month.

On June 4 Mr. Lloyd George went to Liverpool and asked for rifles, guns, shells, fuses, explosives. He besought the workers to abandon their trade union restrictions during the war, promising that the Government would restore these on the declaration of peace. The labour of women, he declared, ought to be introduced into shell factories here as it was already in France. Six days later he met in London the representatives of about twenty leading trade union organisations, and discussed with them the munitions position, especially the methods by which the labour force might be augmented, and how loss of time and efficiency through disputes could be prevented.

At Cardiff, on June 11, he pointed out that there were three ways of proceeding: (1) By setting up two or three national factories in the district and making in them shells only. If that plan were preferred, lathes and other suitable machinery already in the district must be requisitioned—there was no time to wait for new plant. (Leeds and one or two other places in the North had already adopted this method.) (2) By the workshops in the district devoting their machinery to the production of shells on their own premises; in which case they might have to purchase fresh plant—certainly gauges (a method favoured

in Lancashire and among French manufacturers). (3) A kind of combination of both methods.

At Bristol, on June 13, he returned to the subject of trade union customs and restrictions, and again pressed for the introduction of women and unskilled labour into the jealously guarded province of the skilled. We find this problem of dilution recurring over and over again through 1915 and 1916, and even later, though on paper it seemed to have been solved at quite an early stage. It was a most vital problem. Other labour questions grew formidable at times throughout the war—disputes over wages, hours, food, drink, discipline, anti-war movements; perhaps none of them was so difficult, so delicate to handle as dilution. To try to ride roughshod over trade union susceptibility would have led straight to disaster.

On June 9 the Act setting up the Ministry of Munitions of War was passed, munitions being defined as "anything required . . . for war purposes, and including arms, ammunition, warlike stores or material, and anything required for equipment or transport purposes or for . . . the production of munitions." The Munitions of War Bill was introduced a fortnight later and passed on July 2. The Act classified and extended the powers of the State over workers and factory owners already taken by the original Defence of the Realm Act and the addition of March 23 to that Act. It made the Board of Trade referee in all unsettled disputes between employers and employed, and the settlement might be effected by any one of these three tribunals:

(*a*) The Committee appointed by the First Lord of the Treasury known as the Committee on Production.

(*b*) A single arbitrator to be agreed upon by the parties

or in default of agreement appointed by the Board of Trade.

(*c*) A Court of Arbitration consisting of an equal number of persons representing employers and persons representing workmen, with a chairman appointed by the Board of Trade.

The employers and employed were to agree together which of these tribunals should be chosen; or, if they could not agree, the choice should be made by the Board of Trade. Lock-outs and strikes were forbidden, and all persons engaging in them were guilty of an offence. Employers who locked their men out were liable to a fine of up to £5 a day for each man locked out, and employees striking were liable to the same fine for each day of their offence. Munitions tribunals, composed of employers and employed, chosen by the Minister of Munitions, were to be set up to try cases and impose fines; the Admiralty being substituted for the Minister of Munitions in the case of offences against the Act in the dockyards.

The Act limited the profits of controlled establishments. They were to take not more than 20 per cent over "the average of the amount of the net profits for the two financial years of their establishment completed next before the outbreak of the war, or a proportionate part thereof." Any profits exceeding this were to be paid into the Treasury. All proposed changes in controlled factories as to wages and other forms of remuneration were to be submitted to the Minister of Munitions.

Important provisions in the Act dealt with trade union restrictive rules and customs which were to be suspended in these establishments; the Board of Trade deciding in case of disputes whether a rule or custom actually restricted production or not. In a

schedule the Act declared that no change in these rules and customs made during the war should prejudice the workers' position or the trade unions after the war.

Mention should be made of the "leaving certificate" which this measure introduced into war industry. Devised to prevent one acquisitive firm from drawing away workers from another—a common grievance at the time—it caught a good many innocent firms by surprise. Also it was galling to labour; and, after being amended by a later Act, it had to be abandoned. It forbade employers to give work to a man who within the previous six weeks had been engaged elsewhere on munition work, unless the applicant could show a certificate proving he had left that work with the employer's consent.

Finally, the Act could make rules authorising the wearing of badges by those engaged on munitions and other war work. The badges were devised to protect the sensitive from slights. They became the subjects later of a good deal of satire, some of it severe. But it must be said of the workers who wore these emblems that, after all, they were only in the fashion; there must at one time during the war have been tens of thousands of badged people who had never been within a munition shop or dockyard. Most of us wore a button or something. The term "indispensable" acquired an immoral sense in the war; and yet if there were indispensable men of military age and physique anywhere it was in the munition factories. The second best thing to serving at the Front was, after all, working on munitions of war at the Base.

In the debate on the Bill Mr. Lloyd George showed his hand plainly as to the powers he meant to take

over both sides in industry. Among written trade union regulations he mentioned the provision that a man must not attend to more than one machine, and that women must not take the place of male workers. The unwritten rules were still more "devastating," making it impossible, for instance, for a man to do more than a specified amount of work without bringing himself under the displeasure of his fellows.

What a change was worked by dilution in a year or two! Customs, which it had taken the men decades to secure, were by 1918 dead letters. I recall a visit to Messrs. Hans Renold's chain-making works near Manchester in that year, and watching a whole roomful of women, each in some cases taking charge of two or three automatic or semi-automatic machines; and that experience was a familiar one all over the North and Midlands in the latter part of the war.

The Minister turned to the hotly disputed question of piece-work in factories. He blamed employers in the past for discouraging output. "You have earned £10 this week—monstrous!" he represented an employer as saying of a man who had worked harder than his fellows and produced a large output; and, accordingly, down would come the rate of remuneration for piece-work. Nor did he mince matters when speaking of employers who welcomed other employers' men. It was "pilfering." That evil must be ended. As it was, if a man was slack or disobedient, he had but to go off to the next shop to be received with open arms. It was destructive of discipline; and it had worked grave harm in the war factories.

The dearth of labour was a great anxiety, as we have seen, in the spring and early summer 1915. The search for the skilled men who had enlisted had

been only partially successful as regards our forces in France, whilst those who had been drafted off to India were simply not recoverable. The Minister announced that, to avoid industrial compulsion, the trade unions had arranged with him to find the labour by voluntary means. They asked for seven days in which to accomplish this. The Government had agreed, and the Board of Trade, Ministry of Munitions, and War Office were helping the trade unions in their quest. The plan was to recruit skilled men at present employed on ordinary commercial work. The conditions of contract for these new munition volunteers were :

(1) The men were to be paid the district rate of wage. But if this was under what he was making in his late employment, the difference would be made up in his favour.

(2) Railway fare to start on his new occupation, and half-a-crown a day subsistence allowance for seven days' work. If within travelling distance, not exceeding half an hour, the cost of the worker's railway ticket daily; the employers to pay both fares and subsistence allowance with the wages.

(3) Any workman transferred from his employment under this arrangement should, if found suitable, be guaranteed employment during the war for a period not exceeding six months.

This labour recruiting scheme produced about a hundred thousand men in June and July, but many of the volunteers were already at work on munitions or war work elsewhere, directly or indirectly; whilst others were doing important work of different kinds, and there were vigorous protests among their employers, which a committee of the Ministry of Munitions sat to consider in July.

The Munitions of War Act put into the hands of the new authority its weapon; and, short of the conscription of labour outright, it is not easy to imagine a more trenchant weapon.

> O, it is excellent
> To have a giant's strength; but it is tyrannous
> To use it like a giant.

Whether or not from the wish to act up to that maxim of mercy, it is certain the Government refrained from drawing its weapon when the miners in South Wales, soon after the passing of the Act, broke the second clause, dared the munition tribunals and the £5 a day fine, and came out on strike. In that crisis there is no doubt that not only the new Act and the new Ministry, but the whole new munition movement were threatened with ruin. It was flat defiance on a formidable scale. To put a quarter of a million strikers in a tribunal court and fine them for each day of their offence was not a working proposition; a Cromwell or a Clive could not have done it. It might have been feasible to take stark action against the ringleaders. But, actually, Mr. Lloyd George chose a more prudent, and, for munition purposes, a more productive way. He went down to Wales and talked the men out of it. The Act seemed to many people to have received its death-blow. It visibly tottered. And what Act of Parliament, suddenly scorned and defied by a great defiant body of workers in this manner and during a national crisis, would not totter? However, the storm subsided, the men went back to work, the Act recovered. Even its penal provisions, which appeared to be reduced to nonentity and

contempt, though comatose for a while, remained alive and were used in emergencies of a more manageable nature.

The incident may be recalled as the first blow and the worst blow which the munition movement received between May 1915 and November 1918. During those years there were strikes and there were many hot disputes, in which the three parties—labour, capital, and the State—were involved. The nation was startled and anxious whilst these disputes continued; and there was much invective and censure and talk about German money and influence indulged in by lookers-on. Especially there was censure by lookers-on who themselves were neither engaged on munitions nor engaged at the Front, for inactive bodies quite naturally run to censure and invective. According to Shakespeare—who provided for everything, even the Ministry of Munitions—they are like the fishes—"ever . . . do a vessel follow that is new trimm'd." But, as we see when we survey the munition movement as a whole, these disputes were far less damaging to the cause of output than often they seemed. "The small fly on the pane," in periods of great anxiety, can bulk as the black ox on the distant plain. Our perspective as regards labour was often wrong during these years. It is a proven fact that the actual output of munitions through the most notorious disputes of 1915–18 was affected adversely by only a minute fraction. The confusion which prevailed in munition methods before the summer of 1915 was more fatal to the delivery of the goods than any combat which shocked public feeling between that time and the end of the war. I know that many people in munition factories and

shipyards do not agree with this. Not a few at various times gave me their views and these were dark. But, surveying the movement as a whole, it is clear to me that the partnership between the three sides to that movement was a marvellously successful one. By their fruits largely we must judge movements as we judge men; and the fruits of this movement did ripen to a mighty harvest.

Discretion and drive, give and take—that was the policy which saw the nation through crisis upon crisis. It is doubtful whether we should have shown so good or quick a result by a Draconian method, by conscripting labour outright in 1915 or 1916. That could have been imposed on the workers, on condition of all the great industries being, by the same stroke, conscripted or nationalised. But it would have been a prodigious change to carry through during the struggle. It would at first certainly have retarded output.

Before the Munitions of War Act was passed, before indeed the Ministry of Munitions was formally set up by Parliament, the establishment had started at 6 Whitehall Gardens. The first gathering of the Minister and a few of his associates was on May 26. The staff was then about *half-a-dozen*, and it is recorded that the supply of furniture was insufficient even for their modest needs. Three years and a half later, when the Armistice closed the fighting, the aggregate staff of the same Ministry was approximately 25,000, 60 per cent of whom were women and girls.

Sir Hubert Llewellyn Smith was made General Secretary within the next few days, Mr. Beveridge, Assistant Secretary. By May 31 the Secretariat began to take form. Dr. Addison was made Parlia-

mentary Secretary on June 9, and soon afterwards Major-General Sir Ivor Philipps became Parliamentary Military Secretary. Sir Percy Girouard was made Director-General of Supply, with four Deputy Directors under him, namely: (1) Colonel Glynn West—lent by Armstrong Whitworth—Shells; (2) Mr. G. M. Booth, Central and Local Organisations; (3) Mr. Eric Geddes—lent by North-Eastern Railway—Rifles, machine-guns, small arms generally, and optical instruments; (4) Mr. Charles Ellis, Guns. Later Mr. Ernest Moir took over machine-guns as a separate department. By June 15 this munitions organisation was transferred from Cecil Chambers and the War Office to the half-finished buildings of the Department of Agriculture and Fisheries in Whitehall Place, henceforth known as Armament Buildings. Lord Moulton, Director-General of Explosives, had started his work in October 1914. In January 1915 he was acting as a War Office head, and was housed at Storey's Gate, where he continued after the change over. On June 23rd the Engineering Munitions—later known as the Trench Warfare—Department, under Mr. Roger at the Board of Education, and the Munitions Contract Branch were also transferred from the direction of the War Office to the Ministry of Munitions. On July 5 the responsibility for Inspection was transferred from the War Office to the Ministry. The responsibility for that immensely important province, Design, was not transferred till November 25, 1915, when the Ordnance Board was replaced by the Ordnance Committee. Another important date is August 9, when an Inventions branch was formed to deal with proposals relating to munitions supplied by the

Ministry. This new department became responsible on August 23 for the Administration of the Royal Ordnance Factories.

Thus by August 1915 the new Ministry had "a local habitation"—though a somewhat scattered one —"and a name." Also it had its staff, but for some time this staff was in a state of flux. By the end of July 1915 it had already greatly increased; and, in fact, all through the war as output grew and the requirements of the Army varied, now for one form of munitions in great quantity, now for another, it was necessary to add to and rearrange the organisation. For instance, Mr. (now Sir) Charles Ellis, the Managing Director of John Brown's armament works at Sheffield and Glasgow, at first had charge of guns of all calibres. He continued in this post till October 1916. Then he became Director-General of Ordnance Supplies with eight sub-directors, namely, those for Heavy Artillery, Small Arms Ammunition, Machine-guns, Rifles, Shell-filling, Salvage, Woolwich, and Enfield; whilst Sir Frederick Black was Director-General of Munitions Supplies, a huge department which, however, was of course chiefly concerned with metals and other materials. In 1917 Dr. Addison turned several National Shell Factories into gun-repairing factories where heavy artillery was passed over to Colonel Glynn West. Later in that year Mr. Churchill formed his Council, each member of which had a group of subjects, and on this Mr. Ellis had a seat. Finally, in 1918, he went to France to organise the Mission Anglaise de l'Armement, and later the Commission Internationale Alliée des Munitions, which were designed to link up and bring into close touch the work and needs of the Allies generally;

the latter body was actually being established when the Armistice on November 11, 1918, stopped further munition activity.

What occurred in regard to Mr. Ellis, who started simply with " Guns," was common to various departments and officials, unpaid and paid, of the Ministry. It is often said that many mistakes were made by the Ministry during its three and a half crowded years. Mistakes, large and small, there were. But the very fact that the organisation was constantly changing, as it grew, saved it from the rigidity of slow movement almost inseparable from old-established and decorous departments of State. Rigidity is exactly the quality that would have proved fatal to the success of the munition movement; for that movement from start to close was nothing if not one of swift conversion from one form of manufacturing activity to another; and the organising intelligence had to keep abreast always of the creating effort.

The Ministry, like the manufactory, had essentially to be plastic, quickly adapting itself to the demands of the fighting front. Before the close of July 1915 the staff had already been doubled. Altogether about ninety business men, many of them taking no salary, had joined in various capacities. The Ministry was particularly devoting itself to the speeding up of the contracts already placed by the War Office, and to developing fresh sources of supply at home and abroad.

As finally organised, the Ministry of Munitions consisted in November 1918 of ten groups dealing with:

1. *Secretariat.*
2. *Finance.*

3. *Design and Inspection.*
4. *Iron and Steel*: including forgings, castings, and stampings, factory construction, building bricks, coal supply.
5. *Materials*: including non-ferrous metals, railway materials, inland transport, overseas transport, forwarding department, optical munitions, glassware and potash production, mineral resources development, Government rolling mills.
6. *Explosives.*
7. *Ordnance*: including gun ammunition manufacture, gun ammunition filling, area organisation, small arms ammunition, timber supplies, gun manufacture, small arms and machine-guns, machine tools, gauges, Royal Ordnance Factories, department of engineering.
8. *Aircraft.*
9. *Warfare*: including trench warfare and tanks.
10. *Labour.*

The most anxious year for us in the war is commonly regarded as 1918, owing to the German offensive of March 21, and the pressing back of the British and French Armies. I suggest that 1915 may have been more perilous than 1918. In 1918 our resources in munitions, our reserve in shells and guns of all calibres, were immense: in 1915 we had no reserve worth speaking of, and the co-ordination of our national industry for war purposes was then only being planned. On the other hand, Germany before 1918 had reached her zenith in war industry and was clearly on the down-grade. She

was acutely suffering from the blockade in regard to material for munitions. Labour conditions, moreover, were greatly harassing her military effort. But in 1915 the blockade was only lightly felt. Germany then had a great stock of material, and labour was not the menace to her that it was to us. She was then by no means fully developed on the industrial side, but her organisation was far more forward and scientific than ours. Sir Douglas Haig in his last despatch alluded to our escape at the Battle of Ypres, October-November 1914, as a miracle. Was not our immunity in 1915 at least in the nature of the miraculous?

In a speech in Parliament, July 29, 1915, Mr. Lloyd George touched on the question of night shifts. Here is an amazing fact: *after we had been fighting for our lives on the Western Front for fully ten months—and were short of shells, guns, machine-guns, almost every form of land warfare munitions—night shifts were still exceptional even in the professional armament works!* An official census of the machinery of the entire kingdom showed only about one-fifth to be employed for war purposes on night shifts. The remainder was used for one shift in each twenty-four hours—nine or ten hours' work, followed by a rest for the next fourteen hours! The fault was not the armament firms'. It was due to the dearth of skilled men, and to the fact that ordinary commercial labour had not yet been methodically drawn on for munition work. By the close of July something had been done to bring in this unrecruited source of labour; the Ministry of Munitions, with the aid of the Labour Exchanges, secured about forty thousand men and women, skilled and unskilled, for the arma-

ment factories to work the idle machines and start night shifts. But this census not only showed that by far the larger number of machines lay idle through the night; it showed that, even with every machine working two or three shifts in the twenty-four hours, we should be woefully short of machines for a great increase in munitions. Thus we were short of machines for making the heavier shell for which the demand was more and more urgent.

(1) The shortage of machines, (2) the idleness through the night of most of the machines which were fit for the purpose, (3) the dearth of skilled labour—these were not the only difficulties which met the munition organisers almost everywhere in the summer of 1915. The difficulty over the Trade Union restrictions and customs had not been removed by the Treasury Conference and the legislation that followed. Output was still being checked by these restrictions, even as regards the limited number of machines at work on day and night shifts. Mr. Lloyd George cited an instance on July 29 in the House of Commons: coppersmiths had just struck work because plumbers were called in to their aid! One of the chief organisers of the Ministry at that time, with a roving commission through the country, has told me: "Our difficulties were immense at the start—it was many months before we really began to see light." Most people who were behind the scenes then would say the same. Starting to make the tools with which to make the munitions at such a period certainly needed faith.

But the Ministry of Munitions had to drive on in the face of all obstacles. It had to provide for years of war ahead, though industry was not yet half

organised for the needs of the immediate future. A programme of sixteen National Shell Factories was resolved on, several of which were to supply deficiencies in particular parts of shell, such as fuses and cartridge cases. After a conference at Boulogne between French and British authorities, who compared notes as to their respective needs, it was determined to add to these sixteen ten more factories, in which woman labour would have to be largely employed. They were to be run by the Boards of Management under the Area Organisation which Sir James Stevenson began to form and control in 1915.

The news of this programme stirred and heartened the country and the Army abroad. Only experts in armament work fully realised, through hard practice, what it meant to set up a new shell factory, starting absolutely from the beginning, and the length of time that must elapse before the first delivery of the goods. It was probably as well the country did not understand this; the knowledge would merely have damped down enthusiasm. It was right to tell the full truth about the shortage in munitions, shells, guns, everything; to stiffen the nation to a great effort. That was now giving away no secret to the enemy. But no good would have been served by announcing that those twenty-six factories could not be actually producing output in much less than a year. Such, however, was the truth, as these examples show:

(1) A National Projectile Factory was proposed July 8, 1915, and sanctioned August 17. After the ground, which was marshy, was prepared, the iron work started, September 25. Power was installed, and much of the machinery simultaneously ready,

March 26, 1916. By the opening week of June the first shells were produced, and by July upwards of 50,000 6″ and 9″ shells had been turned out. So, in this case, it was a year before the factory was in full blast.

(2) Negotiations opened in August 1915. In September the foundations were laid, and light railways laid round the site. Five weeks later the roof was on, and by the second week of January 1916 the main buildings were almost completed. Meantime engineers had been making the plant, and by this same week in January the first of the presses were installed. Early in March the furnaces began, and by about the middle of the month the presses for punching out big-calibre raw billets into rough shells were all ready. At the same time the repairing plant to keep the machinery in perfect-going order had been added. At the end of May forges, shell-turning shops, repairing shops were at work. Each operator had a single task, for which he was timed to a second. If a machine broke down, the tool room, being well ahead, had another ready to put in its place. Finally, by the end of June 1916 each worker was expert in his or her task. The great majority of these workers were not skilled engineers qualified to enter any works and ask for a job. But to make shells well and speedily, science could devise no better method than here adopted. The factory was created and in perfect working order in about ten months.

(3) July 16, 1915, Cammell Laird of Sheffield were asked to undertake a National Projectile Factory. Their scheme was submitted on July 23 and sanctioned on August 17. August 19 the first sod

was cut, and on September 25 the first ironwork erected. Lay-out and tools were arranged for the production of a 6″ shell, but owing to changed decisions by the authorities as to whether the type should be Mark XVI. or Mark IV. of this shell, some delay and extra work were involved in March and February 1916. April saw about half the machines delivered and production started. May 27 the first 6″ shell, May 31 the first 9·2″ made and passed into bond. July 15 the contract weekly output of 2000 9·2″ shells reached. August 19, 1916, exactly a year from the day the first sod of their Nottingham factory was cut, 17,842 9·2″ shells and 23,519 6″ shells had been passed into bond.

(4) July 1915, Hadfields of Sheffield undertook the construction and management of a National Projectile Factory at their Hecla Works for the production of at least 4000 a week of the 9·2.″ In August there was a definite undertaking to produce :

1000	a week	within	9	months.
2000	„	„	10	„
3000	„	„	11	„
4000	„	„	12	„

Each of these stages was anticipated by about a fortnight, and before the end of 1916 the output was 50 per cent above the contract.

These four are typical examples of war-time form under tremendous pressure and urgency. Shell-making is a simpler task than the production of many other kinds of munitions. Unskilled hands of both sexes, as every one now recognises, can be soon trained to most of its operations. Even so, a year must be allowed, however urgent the demand, before

the factory can be completed and the goods delivered in anything like bulk.

The British offensives of 1917 were only practicable on a massive scale[1] because shell factories were designed and built in the summer of 1915, and began to produce a large output in the following year.

[1] And the offensive in modern war is cheaper than the defensive, cheaper even in life. Taking British casualties during the defence against the German onslaught of March 1918 at the figure 100, then our casualties in our offensive on the Somme, 1916, were 60; in Arras-Vimy, April 1917, they were 52; in Messines, June 1917, they were 34; in Ypres, July-August 1917, they were 38.

CHAPTER III

WOOLWICH

There has sometimes been a tendency to forget Woolwich when recounting the great munition feat. But Woolwich is the wrong place to forget: we could not have won the war except for its resources and ingenuity in the earlier part of the struggle. Without Woolwich we could not have survived 1915. Its works and output grew with those of other factories through the later stages of the war, but from the very start Woolwich threw itself with immense effect into the task of producing munitions. Those were days when, except for Enfield and Waltham—comparatively small establishments—and a few armament firms such as the Coventry Ordnance Works, Vickers, Hadfields, and Armstrong Whitworth, the Army had no one in its difficulties to turn to save those who worked the great Arsenal. "Try Woolwich!" was the first and final resource when a sudden, pressing demand came from the Front for guns, gun carriages, small arms, small-arms ammunition, shells of all calibre for guns and howitzers up to 15″, and innumerable accessories.

Woolwich did not then, or later, make aeroplanes; and, though it was repairing tanks at the close of the war and in 1919, it did not produce them. But it was a perfect epitome of the established arms of all kinds.

Shells, for Army and Navy alike, it created and completed on the spot, from the raw billet upwards. It made cartridge cases, fuses, gaines, primers, detonators in every detail; and filled shells from its stores of lyddite, cordite, T.N.T., etc., ready within the Arsenal magazines or fetched by lorries from a certain ample storage of explosives kept within easy distance of its own neighbourhood. This explosive may not have been accessible to attack from the air, but Woolwich was always open to attack. Its exact position obviously was known to the enemy. It lay on the fixed highway of German airship and aeroplane travel. It offered a heartening target of two square miles for the bomber.

Of all vital spots in the whole country, including even the organising headquarters of Army and Navy in Whitehall, here was the mark of marks for the hostile airman! A few dozen bombs well planted in the midst of its gun and shell shops would have been a showy and a serviceable German triumph. Yet in over three and a half years the enemy airmen only once succeeded in reaching their mark!

Zeppelins first sought Woolwich in February 1915; they did not touch it. They came again several times, without result. At length on October 13, 1915, six bombs were dropped within the Arsenal. Five were incendiary, and one passed through the roof and upper floor of a machine shop and caused a fire, which was quickly put out, thanks to the pluck and presence of mind of the men in the building. The sixth bomb was a high-explosive one. It burst against a crane in the roof of a machine shop, killing one man and injuring a few others, besides destroying a machine or two. That represented the total damage done to

Woolwich during the war by airships and aeroplanes—a humiliating and ridiculous total from a German military point of view. Woolwich was fair game in the early part of the war, when Pomeroy and Brock bullets were unknown, when we had not the means to defend ourselves well against Zeppelins. It was not only fair game, it ought to have been easy game. Yet Woolwich went, virtually, scot free. Of course such precautions as were possible were taken to protect the Arsenal in those earlier stages of the war by extinguishing all lights at an air raid warning. Woolwich was shut down sixty times during the war for airships and aeroplanes; whilst, later, other and more offensive precautions could be taken by anti-aircraft guns and attacking aeroplanes. Still, the failure of these air attacks was astonishing; they merely succeeded in losing Woolwich perhaps one week's work during three and a half years. Beyond a theory that the bends of the river may have perplexed them, there is no explanation of this immunity except want of skill in the raiders.

The service done by Woolwich, throughout the war and notably in its early stages, has not been realised by the public because that service was not only (1) creative, but also (2) advisory and illustrative; a fact not well understood. As to this second branch, Woolwich did not profess actually to train munition-makers outside its own staff, but it was always ready to receive them, and give all the advice about the making of guns, shells, etc., which was needed by novitiates—as well as experts—in armament. The C.S.O.F.[1] can tell a story of some manufacturers

[1] Brigadier-General C. P. Martel. He served for many years under Sir Frederick Donaldson, formerly C.S.O.F. at Woolwich, who went down in H.M.S. *Hampshire*, with Lord Kitchener, in June 1915.

whom he wished to employ on gun work. But when they came to Woolwich and saw the nature of the task, breech mechanisms, etc., one of them cautiously remarked, "We would like to take some work from you, but it's no use your asking us to carve in steel!" As a fact all sorts of people "carved in steel" and other material once the munition movement was fairly going. Gun carriages, which the Arsenal produced and repaired on a large scale, are more difficult to make than guns; yet Woolwich, taking its courage in both hands, gave such work to non-armament firms, often entrusting them with the whole of the complex detail of a carriage, and was not once let down. In 1916 and 1917 alone, Woolwich turned out ten thousand new and repair carriages and war vehicles of various kinds from its Royal Carriage Department.

To understand the need of the expert's advice and practical illustrations at the start of the munition movement among commercial firms, we must scan a list of some of the conversions in 1915 and 1916 from peace to war work. I have come across a few instances which help to show how the great bulk of British manufacturing industry was absolutely revolutionised for war purposes in those years. I find one or more instances of a bridge-builder turned into a trench bomb maker, a railway signal factory turned into a gun-sight maker, a sewing machine firm into a maker of gaines. A Court jeweller became a maker of optical instruments; a cream separator maker—primers; a gramophone maker—fuses; a lead pencil maker—shrapnel; a paper maker—trench and aeroplane bombs; a cloth factory—hand grenades; a gas geysers maker—aeroplane tanks; a yacht builder—seaplanes; a firework firm—hand grenades; a church

decorator—aircraft planes; a wire netting maker—complete aeroplanes except the engines; a boot and shoe machine maker—gun mountings; water meter factory—fuses; window frame makers—shells (150,000 a week); well sinkers—trench and aeroplane bombs; syphon maker— fuses; sheep-shearing firm—shells; music roll maker—gauges; textile manufacturer—field kitchens; baking machine maker—high-explosive shells; Birmingham jewellers—shells; printers' metal and plates—shrapnel; bedstead makers—shells, fuses, and primers; carpet makers—ditto. It is a pity Lewis Carroll had not such sources to draw from whilst he was writing *Alice in Wonderland*, or *The Hunting of the Snark*. The munition crusade had its broad comic side as well as its tragic.

Not individual firms alone had to put away ordinary commerce for war material, whole cities and industrial districts had to do likewise. One city in August 1914 had a great business in fabrics. It was converted into a munition metropolis, and by and by was turning out 120,000 shells a week, twelve million fuse components, 100 tank hulls, 25 tank gear boxes, 50 searchlights, 200 machine-gun emplacements, and half a million aircraft details.

Absolute amateurs, on the strength of a lathe or so, flung themselves into the movement. Very likely they had never heard till 1915 of a fine-limit gauge, did not guess what a primer meant. No matter. We have often heard of the North Wales baronet who converted his saw mills into a shell factory, and made his daughter chief turner; and with the aid of one trained mechanic produced shell with a percentage of faultiness of 1·8 though the corresponding average for the whole munition area was 8·1. And

there were many instances of the kind, even of enthusiasts who fitted up their bedrooms with power press or lathe and manufactured fuse components, even fair-sized shells, which passed the Government test.

Of the thousands of controlled firms and sub-contractors making munitions in 1916 and 1917, the vast majority—probably something like 90-95 per cent—had never turned out a component of gun or shell, etc., before the war. The little firms, having no machines worth mentioning, could not undertake elaborate tooling operations—"carvings in steel"—far less could they turn out a complete shell or gun. But, once they were marshalled, and their work in some degree co-ordinated, they could turn out in quantity some small munition part or component, such as pins, screws, etc., and thus render valuable service.

It was in guiding or advising these newcomers, innocent of war and its material, that the Royal Arsenal, with its extraordinary variety of output, its experience, and its prompt advice, was so valuable. Quite early in the war fifteen hundred representatives of ordinary commercial as well as of the regular armament firms were shown everything they wished to see in one department alone, the East and West Laboratories where ammunition components are made. That department not only manufactured almost every kind of component, but, as the war developed, it manufactured many of these components in a variety of forms.

Early in November 1918, Woolwich was supplying ten different kinds of service shell, and forty-three experimental kinds—with fifteen different service fuses and almost endless experimental ones. Woolwich

was experimenting as well as producing through the whole war. Thus at the close of the war it was experimenting on new forms of aerial ammunition which would have played a large part had the struggle continued. Woolwich, through its immense expert and practical knowledge of munitions of war, was expected to test and advise on all manner of new inventions, which were offered first to the War Office and Admiralty and later to the Ministry of Munitions. It had incomparable facilities for that purpose.

People not only came to Woolwich from all quarters to observe, and inquire as to some point in munition work they were doubtful about, Woolwich had distributed many of its experts throughout the country: we found in factories all over the North and elsewhere, through the war, Woolwich instructions and instructors in munition-making.

On August 1, 1914, Woolwich had a total strength in its Ordnance Factories of 10,866—all men. During the first week of war it took in another thousand, and by the end of 1914 its total strength had risen to 23,000. It went on developing till the Armistice, when it was employing 74,000 workers, 27,000 of whom were women.

These figures relate to the Ordnance Factories, the actual munition-makers alone. Including the Army Ordnance, Navy Ordnance, and Inspection departments the totals would be, on August 1, 1914, 15,559; and at the end of November 1917, when output was at its highest at Woolwich during the war, there was a total of 96,325 men, women, and boys employed in the Arsenal. In fact it was then one of the great English cities, and its workers had largely to be housed in huts, hostels, and a garden city, built for the purpose

in 1915 onwards at Well Hall and Eltham, a few miles from the works. In 1919, as a result of war growth, the acreage of the Arsenal and Dockyard covered by buildings was 285, and these buildings were fed by nearly 150 miles of both standard and narrow gauge railways and by 27 miles of roadway. There was nothing approaching it in this country; and, with the exception, I suppose, of Krupp's, there has never been an arsenal in the world to match or surpass it in extent.

The power figures in certain sections of the Mechanical Engineering Department during the war corresponded in vastness with the above. For instance:

	August 1914.	*During War.*
POWER SECTION:		
Maximum demand	2100 k.w.	11,000 k.w.
Maximum weekly output . . .	106,000 units	1,140,000 units
Total units of electricity distributed during war .	163,380,000 units	
HYDRAULIC SECTION:		
Maximum weekly output—		
(High pressure)	2,600,000 galls.	11,900,000 galls.
(Low pressure)	9,200,000 galls.	31,600,000 galls.
Total galls. of water pumped:		
High pressure at 800 lbs. per square inch .	1,840,600,000 galls.	
Low pressure at 50 lbs. per square inch .	4,026,680,000 galls.	
GAS SECTION:		
Maximum weekly load . . .	4,200,000 cub. ft.	31,500,000 cub. ft.
Total cub. ft. distributed . .	4,557,923,000 cub. ft.	

During the war there was no failure of supply at either the Central Power Station or the Gas Factory. The machinery purchased by the department for use in the Arsenal amounted to 13,000 items at a cost of, approximately, £2,107,000.

It is impossible to state the whole output of Woolwich, and the increase from year to year, for the number of different kinds of munitions was so great, but a few figures should be cited. The demand on the Arsenal for small-arms ammunition was tremendous and insistent at the start. From three millions a month at the beginning of the war it rose to twenty-four and a half millions a month after a year's fighting. It went on increasing to fifty millions and there was one record month in which it stood at sixty millions.

By 1918 the stock of small-arm ammunition was so large that output was then being reduced and workers were being discharged from this department. But suddenly, when the German offensive of March 21 started, there was a fresh and imperious demand, and a special effort had to be called for to make good the losses in France. Workers were brought back, and presently Woolwich was producing, continuously for three months, forty-eight million rounds a month.

In August 1914, 1500 men were engaged in the shell-filling factories; by the close of 1915, 11,000 men and women were at work there. They were filling almost anything and everything, from a minute detonator to a 15″ shell. The new hands, as they were pressed in, had only the most exiguous opportunities for training, or for learning even the rules in the danger buildings. All, at this period,

necessarily was rush and pressure. Yet only a few trifling accidents happened.

The first woman was entered on the Arsenal books October 18, 1915. Soon after, women poured into the filling and small-arms ammunition factories of Woolwich, as well as into the components factories for fuses and cartridges, etc. The experiment was a success, thanks largely to the zeal and skill of Miss Barker, known as "the mother of 27,000." She organised schemes of recreation; looked to the health and comfort of the girls, and started a benevolent fund. Finally, at the close of hostilities, she so managed the discharge of twenty thousand women that there was neither friction nor angry discontent.

Nowhere perhaps was the *esprit de corps* among great bodies of women, who volunteered for war work which was very strenuous always, and sometimes hazardous, better than at the Arsenal 1915–1918. During the munition movement, writers and speakers, in order to incite and applaud effort, ran constantly to the superlative. Praise became stereotyped, and uncritical. The habit is usual in propaganda. We incessantly praised our workers at home as we praised our Allies abroad. Often it was sincere enough, for those who visited factories and workshops saw as a rule the bright side only of the shield. But I am confident that, viewing the thing broadly, the praise was not pitched too high as regards the work of the immense army of women which came into the factories from 1915 till the close. The work was not extravagantly paid—those who thought so knew nothing of its weight and its oppressive monotony. Numbers of the women brought enthusiasm, numbers brought a live interest and curiosity to their new task. There

was a touch of romance, the suggestion of a new world, about munition-making. But a few months of routine kill romance, tend to cool the ardent glow of enthusiasm. Yet the women endured steadfastly; and in the spring of 1918, when the greatest strain in the war came upon workers everywhere, they were admirable. At Woolwich this was observable among the women as among the men.

Woolwich was forced to take in all sorts and kinds of men to fill the gaps caused by recruiting for the Army, and to increase hugely its *personnel.* It took in, unawares and through no fault of its own—for in the early rush it could not stay to pick and choose nicely—a sprinkling of firebrands. But only a sprinkling. The bulk of the newcomers assimilated fairly well with the old hands at Woolwich; and when we look at the hours of labour, 1914–18, which were endured (1) normally, and (2) exceptionally, by the workers, we can acknowledge it was hard to exaggerate the value of their services. Mr. William Crooks, M.P., made himself throughout the lyrist of the Woolwich workers. Did he pitch the note too high? I say he did not. Some of the figures as to hours of labour are amazing. Woolwich was working day and night shifts, twelve hours (including, say, two hours for meals) each shift, from the start. *There were men who worked close on one hundred hours a week.*

There were occasions when a pressing order for some form of munitions came from War Office, or later Ministry of Munitions, which meant that men must work continuously for between two and three days if the usual double shift could not be arranged in the particular workshop concerned. And men were found to face that extraordinary strain.

Here are seven examples of hours worked between August 1914 and November 1918 by various groups of men: they show I do not exaggerate the will and strength of Woolwich:

(1) Number of hours worked during the week, 89½. 35½ hours were worked continuously on Tuesday and Wednesday.
(2) Ditto. 92½ hours. 35½ hours continuously on Wednesday and Thursday.
(3) Ditto. 82 hours. 35½ hours continuously on Tuesday and Wednesday.
(4) Ditto. 99½ hours. 35½ hours continuously on Monday and Tuesday. 15 hours on Wednesday. 14¾ on Thursday. 15 hours on Friday.
(5) Ditto. 99½ hours. 39 hours continuously on Wednesday and Thursday.
(6) Ditto. 93½ hours. 35½ hours continuously on Tuesday and Wednesday.
(7) Ditto. 99½. 14 hours on each Monday, Tuesday, Wednesday, and Thursday. 27½ hours on Friday and first half of Saturday.

These authoritative figures are a wonderful revelation. They ought to be read and re-read by miserly critics of British effort in these *anni mirabiles* of war. They throw a flood of light on the question of how we were able to catch up the Germans in munition output despite their long preparation and their science and foresight. But they are still more serviceable in this: they indicate what Great Britain is fully capable of doing in world industry and commerce once an adjustment has been reached between the claims of the producer, the capitalist, and the consumer. We can stand up to the cleverest and the most hard-working nations in either New or Old World if we choose to organise ourselves as we did in the war.

The money for such feats of endurance as these of Woolwich Arsenal workers was good—up to £10 a week perhaps, exceptionally even £15 and over.

But the best men would have been angled for in vain with that bait alone. Men were induced to work at that strain—thirty-five to thirty-nine hours continuously—mainly because they learnt that it was a matter of life or death to this country and her cause for the goods to be delivered without the least delay. If for some reason the munitions they made were not immediately delivered on completion, but lay in the Arsenal for a time, there was openly expressed dissatisfaction ; which offers, I think, fair evidence that the men worked these abnormal hours for other ends besides those of pay.

Since the war was fought and won, there has been a disagreeable reaction in various quarters over munitions. We have heard much about extravagance ; about muddles ; about " doles "—a word that ought never to have been officially employed—and their evil effect on the character of men and women in the munition movement. It was inevitable there should be some change of attitude after the struggle. But in the false light of reaction we see the munition movement far more out of the true perspective than we saw it when praise was lavished, and extravagance rarely mentioned.

The mighty essential fact that should never be forgotten is that the fate of the nation from the autumn 1914 till the summer 1918 simply hung on a great and ever-growing output. It is only by emphasising this, by always putting it in the forefront, that the munition movement can be seen in its right perspective.

I do not believe the reaction will last—it will assuredly not last into history. A statesman long ago made a remark depreciating over-patriotism ;

an opponent countered him well by saying there was something worse than patriotism, namely its recant. That retort might be applied to reaction over the munition movement.

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To envisage Woolwich, to get a fair idea of at once its diversity and its immensity of production during the war, was somewhat like trying to grasp the scheme and scope of a great battle going forward on the Western Front, such as the Somme in the summer 1916. You could drive and walk through miles upon miles of material and seething energy at Woolwich as behind the battles of the Somme, and not the longest day sufficed to show you much more than a fraction of its effort. You might stay an hour or so among the workshops where naval guns up to 15 inches were being retubed and otherwise repaired, and where new guns were being made, as at Vickers, or Beardmores, or Armstrongs, from the rough billets brought from the North. You saw the mighty tubes being tempered ; lifted by cranes and dipped red hot into their baths of hissing oil—that spectacle of wonder familiar enough in Sheffield and Glasgow and Elswick, but in the South of England unknown except in this arsenal.

A few minutes later you were perhaps in some department like the tailors' shop, where women and boys were making trifling little paper cases for gaines or other shell component ; and stitching shalloon and silk bags for the cordite cartridges which fire the shells, armour-piercing and high-explosive, of the heavy naval and army guns and howitzers. In this department were made those delicate parachutes, some of them wrought of the finest white silk, for the

Army's star shells which were so faery a spectacle of the battle front at night; with larger parachutes of silk or of cotton material for aeroplane flares in reconnaissance work. When the shell burst the little silk parachute was released intact, and, opening out through the resistance of the air, it floated slowly towards the ground, supporting its illuminating star. The principle was the same in the parachute dropped from the aeroplane at night.

The war after dark was full of these fascinating spectacles at times, but I think that the most beautiful effect of the kind I saw was not at the Front but at a very quiet spot near Andover one midsummer night. An aeroplane came into the deepest English June-blue over our Hampshire woods and fields and dropped its flare which slowly descended through the rich afterglow and died out gradually as it neared the ground.

Inconsidered items of warfare such as these Woolwich was producing during the war with the same ingenuity and precision it was devoting to shells and guns of all calibres. It was not only producing the actual munitions. Being largely a self-contained arsenal, it had great quantities of machine tools, jigs, and gauges for its own workers. It made its own buildings; it laid its own railway lines.

It equipped its workers for the buildings where shell-filling was done. The precincts of all those buildings where cordite, high-explosive, and other dangerous chemicals are used are divided into what are known as "the dirty" and "the clean." Before a worker stepped on to "the clean," he or she had not only to give up any inflammable substance but to be clothed in material made in the tailors' shop,

and shod in shoes from which brads were absent. Clothes and shoes for the danger buildings were all made at the Arsenal. There were during the war many prosecutions under the Munition Acts for breach of these stringent regulations; girls *would* smuggle in some trifling ornament, men a few matches or other forbidden article. But, considering that tens of thousands of new hands were at work in these buildings, the offences were not excessive in number; and the offenders took their correction in good enough part. The accidents which did occur at the Arsenal during the war appear astonishingly few considering the perilous nature of the high-explosive and the vast amount of it handled. Even a little road grit or dust coming into contact with metal may cause a disastrous explosion, and absolute safety can be ensured only by perfect cleanliness.

But the immunity from danger is no doubt largely to be attributed to the "single purpose," or one quite simple repetition task set to the unskilled workers. That method, a minute division of labour, which will be worth examining in some detail in another chapter, was one of the great secrets of war production in immense bulk. The expression "fool-proof," sometimes applied to the single and extremely simple task repeated like a decimal fraction, is not altogether fair; but it serves to emphasise the difficulty of even quite unskilled and new hands going far wrong in their tasks. Neither Woolwich nor any other arsenal in the country could with good results have taken in thousands of new hands had not this method been widely adopted. It is the only way to produce munitions speedily on a great manufacturing scale.

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A formidable problem faced Woolwich directly it was recognised that its staff must be greatly recruited by outside labour. Where was this labour to be housed, how was it to be catered for in regard to food outside the Arsenal canteens, and what arrangements must be made as to transit to and from work? Hitherto the workers had found their own quarters, either in the district or in London on both sides of the river, and made their own catering arrangements. But with a great body of new workers coming from all parts of the country, Woolwich had to organise an entirely new scheme. It had to find quarters and provisions for the newcomers by tens of thousands, to find trams and trains for them too. It had promptly to start what in the broad sense amounts to welfare.

Mr. A. H. Self laid the outlines of a housing and provisioning scheme, and I doubt whether a more practical and human one was worked out in any munition district. A great deal of the Arsenal's area itself is low-lying, considerably below the level of the river. That is one of the defects in the site. On summer days in fine weather this area with its verdant grass and reeds is rather pleasant to the eye. It has landscapes, notably looking towards Shooter's Hill, with a certain suburban comeliness of their own. They compare well with many crowded places in the North and Midlands where munitions were produced in great bulk during the war. Still the place does not look promising from a hygienic point of view. When you turn from the Arsenal and its immediate surroundings and pass through Well Hall on to the Eltham ridge, you see at once what can be done by swift and well-thought-out organisation. The Welfare Supervision Department of the Arsenal took over the Garden

City at Well Hall, which included 296 houses and 70 flats built through the County Council. Many of these houses and their gardens are sightly and even beautiful on a summer day. They are well built and ordered throughout. The department also established and supervised bungalows or huts at Abbey Wood, Welling, Well Hall, and Greenwich, which housed between twenty-two and twenty-three thousand workers; and it added hostels at Abbey Wood, Plumstead, Well Hall, and Eltham, which gave capital bedrooms, canteens, and reading-rooms to another five thousand men and women. The quarters were clean and healthy, and it was found practicable to supply the workers with good meals at under a shilling apiece.

The same department made all the travelling arrangements for the workers in the Arsenal and Dockyard. It organised its own railway time-tables, provided for trams and omnibuses, built passengers' shelters and foot-bridges, and an additional railway station, Manor Way Halt on the South-Eastern & Chatham Line when the Arsenal extended in that direction. It set up an Employment Bureau, through which over a hundred thousand workers at various times were engaged by the Arsenal; and this bureau took over labour questions.

Housing, hygiene, feeding, travelling: those are the four indispensable features of what was known as welfare in the munition movement. They were the four absolute necessaries of life where large bodies of workers, both sexes and all ages, were thrown together. It would not have been possible to carry on without their regular and disciplined organisation. But it must invariably be the case that, when you

shepherd workers thus, there arise all sorts of other questions affecting their private lives and problems. Some firms were opposed during the munition movement to their welfare departments intervening in such questions unless these directly affected work and output. But in practice it was often found at the Woolwich colonies and elsewhere that men and women needed and sought advice as to delicate private questions and disputes. A munition-worker, man or woman, married or single, would sometimes be so harassed by domestic and other private worry that the result was loss of efficiency and consequent reduction in output. Thus welfare supervisors had constantly to intervene with a discreet word or two of advice.

Mainly, welfare was and must be a matter of accommodation, victuals, and transit. But so soon as these are undertaken for large bodies of men and women gathered together from all parts of the country, more delicate matters concerning the private affairs of the workers are bound to arise; some one in authority must try to help settle them; and this is where sympathy and tact were invaluable in welfare supervisors. Wordsworth's saying that "men are but children of a larger growth" was profoundly true of many of those strong sons and daughters of toil who ultimately enabled our armed forces to break up the mighty war machine of Germany. These larger children in the ranks often looked for guidance or advice over some difficult private affair, and it was the business of the welfare officer at Woolwich and elsewhere to respond with sympathy.

CHAPTER IV

THE ARMAMENT FIRMS

NOT a little I have said about Woolwich applies to the established armament firms—to Vickers at Sheffield; the Coventry Ordnance Works; Armstrong Whitworth at Elswick; Firths at Sheffield; Hadfields at Sheffield; the Small Arms Factory at Birmingham, and a few others whose names appear elsewhere in this book.[1] They, with Woolwich, saved the position

[1] In April 1915 the Armament Firms were as follows:

Firm.	*Place.*
Armstrong Whitworth & Co.	Elswick, Darlington, Alexandria, Openshaw, Manchester.
Vickers.	Erith, Crayford, Ipswich, Barrow, Sheffield.
Firths.	Sheffield.
Hadfields.	Sheffield.
King's Norton Metal Co.	Birmingham.
Birmingham Metal & Munitions Co.	Birmingham.
Electrical & Ordnance Accessories Co. (Vickers).	Birmingham.
Birmingham Small Arms.	Birmingham.
Dick, Kerr & Co.	Preston.
Cammell, Laird & Co.	Birkenhead.
Coventry Ordnance Works.	Coventry.
Greenwood & Batley.	Leeds.
Projectile Co.	Battersea.
London Small Arms.	London, E.
Beardmore.	Dalmuir and Parkhead.

GOVERNMENT FACTORIES

Royal Arsenal.	Woolwich.
Royal Small Arms Factory.	Enfield.
Royal Gunpowder Factory.	Waltham Abbey.

in the early part of the war by their output of guns and ammunition. Later, by development in all directions, they produced the guns, gun carriages and mountings, the ships, airships, train ferries, torpedoes, and miscellaneous complicated munitions needed for victory. Obviously these professional armourers were invaluable in 1914 and 1915, before the national industry had fully changed from peace to war output; but they were invaluable, too, in 1916, 1917, and 1918, when the amateurs in their turn were producing vast quantities of shells, and parts at least of almost every conceivable form of munition—for the whole munition, except for shells, was rarely produced by the latter.

Broadly, it may be stated that guns and rifles—to take two of the most important arms—were made by the Government arsenals and the armament firms, with the aid of the thousands of ordinary commercial firms and amateurs who began to produce in bulk by 1916, and who supplied innumerable components or parts. Not that the armament firms were fully equipped with plant and labour for munition-making on a vast scale in 1914. Far from it. For years before the war these firms were largely concentrated on the requirements of the Navy, not the Army. The modest needs of the Army before August 1914 were met, unaided, by Woolwich and the other Government factories. One or two of the armament firms in August 1914 were doing a certain amount of work for foreign countries as well as for our own Navy, building ships for Chili, Turkey, and Norway, which when war broke out were added to our Navy. But they were producing nothing for the great conscript armies of the Continent; their shops, so far as military needs went, had been almost unused

since the South African and Russo-Japanese Wars. So they lacked the plant for the immediate manufacture of Army as distinguished from Navy munitions. This was the position of the great Elswick works at Newcastle; and we can take them as an example of what the armament firms achieved in the war.

At the very start the burning anxiety was for ships of war, naval guns, and projectiles. The armament firms had to attend first to these. Armstrong Whitworth added during the war 12 armoured ships, 11 cruisers, 8 sloops, and 11 submarines to the British Navy. Among these vessels were H.M.S. *Courageous* and H.M.S. *Furious*, about which so many wild rumours were launched in 1916. They were two out of the three lightly armoured, very speedy cruisers designed to deal with the "tip-and-run" attacks of the German fleet. The *Courageous* carried, as main armament, four 15″ guns, and the *Furious* carried two 18″ guns. This experiment—like sundry others during the war—happened to be not a fruitful one, but the firm carried out its contract. Besides the ships completed in their yards, Armstrongs were well advanced with the cruiser H.M.S. *Dunedin* when the Armistice came, and were at work upon another, H.M.S. *Delhi*. Among their sloops were four of the "Q" or mystery ships, and four more were under construction in November 1918. The submarines carried Elswick torpedo tubes, ninety-seven of which were produced by Armstrongs for the Navy during the war.

Other naval work included two floating power stations, a self-propelled floating crane capable of lifting 250 tons, two train-ferry ice-breakers to keep clear the passage to Archangel, and two train-ferry

steamers to carry munitions between Richborough[1] and France.

The train ferry may not have been, like the tank, an all-British idea, but it was a quite wonderful engineering achievement of Britain in the war. The steamer carried railway waggons and engines on four lines of rail arranged on deck and converging into two lines at the stern. It was made with ten water-tight compartments, and its draught was under ten feet—to avoid the torpedo peril. Its maximum speed was 16 knots—quite a respectable one compared with one or two of our land railways. Each steamer was turned out in eight months; and on one of them, at the first trip, sixty railway waggons were loaded in less than ten minutes. Adjustable bridges and other mechanism at the points of departure and arrival were made by Armstrongs. The Cross Channel Train Ferry, viewed lengthwise, precisely resembled a considerable section of one of the great English railway lines: the ship itself, thus seen, was hardly noticed: it was the railway turned into an amphibian.

Guns were a mighty contribution of Elswick and its branches to the war. Over 13,000 were made, not counting trench howitzers and the like, or naval howitzers, and this total might have been substantially larger but for the repairing and relining of worn guns returned from the Front, an immensely important work. All the 6-pounder guns for our tanks were made by Armstrongs, who also completed 1413 of the 60-pounder guns and 2661 of the 18-pounders. In round figures they made 9000 guns for the Army and 4000 for the Navy.

The naval guns included three 18″ guns, weighing

[1] See Chapter X. "Richborough and the Transport of Munitions."

152 tons apiece (with projectiles of 3320 lbs.), and large numbers of 15″ and 14″ guns.

At the artillery ranges for Elswick 48,510 rounds were fired in 1918 for proof of material and experimental purposes. It is a mistake to suppose that, here or elsewhere in the country, during crises, and under great pressure, the testing of guns was scamped or dispensed with. It proceeded in the usual way, whatever was happening at the Front.

The earlier orders placed with Armstrongs were not merely for the gun, 18- or 60-pounder, but for the entire equipment of the gun: for carriages, carriage limbers, ammunition waggons (three to each gun) and ammunition limbers. In those days non-armament firms were not yet making gun waggons and limbers. As for gun carriages, these with a few exceptions had to be left to the experts throughout the war.

Elswick originated the idea of placing the Navy 9·2″ and other guns on railway mountings. It was received at first coldly, but after much discussion was adopted by the Army and became general. Naval guns up to 14″ were mounted on railways and moved about the Front in 1916. That was a great step forward in artillery work.

In July 1914 the Elswick capacity for naval projectiles was not over 40 tons a week with 1000 cartridge cases and a matter of 500 fuses. The firm was employing less than 2000 men in its ammunition shops. It had to speed up immensely to meet the new orders that came pouring in from Admiralty and War Office. The motor car department was immediately dismantled, and by the close of the first year of war there was a weekly output of 8000 to 9000

shells for the Army. In 1915 Armstrongs delivered over two million shells for the Army and a quarter of a million for the Navy. In 1916 they doubled that output. By that time the National Factories, shell and projectile, were at full blast, and the demand on the armament firms for 18-pounder high-explosive and other shells slackened; on the other hand, the demand for 6″ shells was almost unlimited. Armstrongs were producing at one time 17,000 of these a week.

The total Armstrongs output of shells in the war was 14½ millions.

As so much has been said about high-explosive shells, and our blunder in not supplying them early in the war, it is worth mentioning that the largest number of any one kind of shell made by this firm in a year was 2,900,000 18-pounder; and that these were shrapnel. We suffered terribly in 1914–15 through dearth of high-explosive shells for field-guns and heavy pieces; but none the less, shrapnel was absolutely necessary and invaluable continuously throughout the war. Above ground and in action shrapnel is, after all, the deadliest missile. It is the bullet that kills. Nine out of the fourteen and a half million shells delivered by Armstrongs in the war were 18-pounder shrapnel.

The cartridge case totals at Armstrongs exceeded those of shells, fuses (18½ millions), and all forms of munitions.

At the Birtley factory alone the weekly production of 18-pounder cases reached and kept an average of 100,000, once the shops there, started in 1916, were in full-going order. It dropped below that figure only if the Government failed to supply enough material. Birtley contributed more than half the

eighteen million 18-pounder cases delivered by Armstrongs during the war. There were also two million cases for 3″, 4·7″, and 4·5″ guns, and others for various types—in all, twenty-one millions.

Then there was the filling of between twelve and thirteen million shrapnel and high-explosive shells, for which new factories had to be built at Lemington and Derwenthaugh-on-the-Tyne. Many thousands of unskilled workers, men and women, were handling picric acid, cordite, ammatol, and other dangerous explosives; yet, as at Woolwich, there were few accidents at the filling works. Besides their Tyneside factories Armstrongs filled shells at their Thames Ammunition Works, where three-quarters of a million fuses and a million gaines were turned out; bombs, too, and rifle grenades.

Finally, aviation: Armstrongs supplied over a thousand aeroplanes, starting with 6 in 1914 and ending with 423 in 1918; and they experimented with new types, such as a single-seater high-power fighting scout, at the time of the Armistice. They built three airships, the first rigid one being completed and delivered to the Admiralty in August 1917. The R29 followed in July 1918, and was in regular service afterwards. She sank at least one German submarine in the North Sea. The R33 had two million cubic feet capacity and increased speed. She made her trial trip early in 1919. The shed at Barlow where R33 was built had to be extended to over 700 feet, and the Empress Ball-Room at Blackpool no more than comfortably accommodated two of her immense gas-bags or balloonets.[1]

[1] I have mentioned only the chief forms of munitions which the Elswick Armament Company, as it was originally named, turned out in great bulk.

How was this gigantic production of war material reached ? (1) By prevision and by adoption of the latest scientific method and discovery ; (2) by 70,000 to 80,000 workers, both sexes. Without the first the great armament firms could not have successfully overcome the constant perplexity and difficulty of changing at short notice from one kind of gun and shell to another. It often happened that when a factory had got its arrangements in order for making some particular form of munition, it was called on to produce another form. This was especially so with ammunition and guns. No one could be fairly blamed for these sudden embarrassing changes : they were due to the fact that the character of the fighting had, for the time being, altered. The changes meant waste of time and material ; but they did not reduce the armament firms to confusion and despair, thanks to scientific methods and exact organisation. Organisation, as the war progressed, became a mighty factor. I believe from what I saw and heard about the munition factories in 1917 and 1918 that we learnt more, laid to heart more, about organisation and co-ordination in four years of war than decades of peace had taught us.

Dilution of labour was effected at Elswick, Openshaw, and the other Armstrong factories without great friction. More than a third of the workers were women, who came in as unskilled hands. Tyneside was no more immune from labour disputes, from the industrial ferment of the factories, than Clydeside, South Wales, or the Midlands ; but when we are dwelling on these vast munition totals, it is impossible

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There were minor contributions, too, both to Army and Navy, such as 100 Mark IV. tanks, bullet-proof plates for aeroplanes and tanks, and material for the shell made at National Factories, one of which the Company built and equipped.

to avoid the reflection that nothing could have been done on such a scale without the goodwill of the worker. He was master armourer in the world war.

The Birmingham Small Arms Company, concentrated early in the war, and indeed throughout, on (1) our service rifle, *e.g.* the (1907) Lee-Enfield ·303 bore Mark III. type. This weapon had its unfriendly critics at the start, but with certain minor alterations adapted to short-range fighting it stood the test of war at least as well as any other rifle. (2) On the Lewis air-cooled automatic machine-gun. The Company, to meet the demands of the Army and Air Service, had to increase their personnel from 3500 to 13,000 ultimately. During the South African War they had reached an output of 2500 rifles a week—then the Lee-Metford—but this had fallen away greatly so that for five years before the European War their production of rifles for the British Government only averaged a total of 7000. To keep their works alive, they had to make up as best they could by manufacturing sporting and match rifles, etc. After August 1914 their output gradually rose; till, finally, from a production of 135 a week they reached in round figures 10,000 a week.

The manufacture of the rifle is one of the most complicated in the world of munitions. The Lee-Enfield consists of 131 distinct parts, so that when the output reached 10,000 the B.S.A.C. were producing 1,310,000 rifle components each week; whilst the number of machining operations which these involved was over 15,000,000. The greater part of the Sparkbrook Factory had to be set aside for manufacturing the tools—gauges, cutters, drills, etc.—with which the rifles and Lewis guns were wrought. The intricacy

and extreme precision of the manufacture of the Lee-Enfield and the Lewis gun may be illustrated by the number of gauges employed—1250 for the first and 2600 for the second. The gauge is a very hard counterpart of the particular item of the rifle or machine-gun to be produced. It tests the item; and is itself tested by the master gauge. Among the parts of the Lee-Enfield are the butt; hand-guards, rear and front; fore end; body; barrel; bolt; nose cap; guard; butt plate; magazine case; magazine platform. There is an immense amount of fine work even in the butt which is not observable till one has glanced at the process of its manufacture. The wood used for this component, as well as for fore end and hand-guard over the barrel, is walnut, which is seasoned for three years in a store where temperature must be carefully watched and registered; otherwise the grain will not settle down satisfactorily. Then it passes through a series of rough turning and fine turning processes. These wood components when completed must pass their gauge tests in the same way as the steel components of the rifle.

The barrel's manufacture is much more complicated. Forging the barrel, and afterwards drilling, turning, grinding, boring, setting, and rifling it, involve 85 machining operations. It has to be proved before the rifle is assembled as a precaution against any hidden defect in the steel. The cartridges used in this proof are heated in an oven, and, fired in a temperature well above normal, they set up a pressure of some 25 tons, which is greater than that of the ordinary cartridge. When the rifle is at length finished it goes to the Government range where its accuracy in fire is tested by means of a mechanical

rest or grip, and a telescopic device which is laid on the sights. The test is not tolerant. At a range of 100 feet to begin with, the rifle has to put four out of five shots within a space an inch broad and an inch and a half high. Even at a 600 yards range 10 per cent of the rifles manufactured must get nine out of every ten shots within a two-feet circle. In regard to some of the smaller components of the rifle virtually no tolerance is suffered. They have to answer dead true to the gauge test. Other components get off lighter, for the automatic and semi-automatic machines producing these in great numbers must be affected owing to the inevitable wear and tear of fixings and cutters.

The body of the Lee-Enfield is an extremely complex piece of work. Fresh from the smithy as a rough forging it weighs 5 lbs. After passing through 149 operations, it is fined down to a trifle over 1 lb.

The B.S.A.C. manufactured the Lewis guns used by our Army, building a new factory for the purpose, and increasing their staff of workers for this weapon a hundredfold. From an output of 30 Lewis guns a week in the early part of the war, they finally reached 2000 a week. Some notes on this gun will be given in a later chapter. The Company also produced cycles for the Army, and particularly a type of folding cycle which troops could carry on their back: and they made large numbers of motor cycles for our own and the French Army.

Munition output figures can be grasped so long as they relate to guns and shells. It is when we turn to certain forms of small-arm ammunition, as may be shown later, that they grow so unmanageable. The output of Kynochs at their Lion Works, near Birmingham, is quite a good illustration of this.

Kynochs, strictly, were not an armament firm, but their work may be mentioned here, for from the start it was on an armament scale. The firm was employing under fourteen thousand workers shortly before the Armistice, and at no period during the war was the number over sixteen thousand, yet it contracted to produce twenty-five million rifle cartridges a week; and during the German offensive in 1918 it reached 29,750,000 a week. Kynochs also made 700,000 revolver cartridges a week for the British Government, five million cartridge clips, and 110,000 18-pounder brass cases. What became of all the small-arm ammunition thus produced in unimaginable quantities? Obviously, it was not all *shot off*; for, assuming that if even one bullet in a hundred or in a thousand had found its human billet, the casualty lists of the war would have been far greater than they were. The truth is, an immense mass of small ammunition in war is never discharged from rifle or machine-gun. It becomes part of the inevitable waste expenditure of war. Many battlefields reveal this; whilst as for the course of a retreating army, that is littered with ammunition unused and cast aside. I was struck by this phenomenon in June 1917 whilst passing along Vimy Ridge very soon after its capture by the Canadians. Unexploded grenades, bombs, and rifle cartridges lay in profusion in all directions, as well as smashed rifles; and helmets, chiefly German, but British also, with here and there a French one recalling a long-past combat. There were spots about "The Pimple" and a crater near by where thousands upon thousands of rifle cartridges lay broadcast over the tortured ground. I could scarcely step clear of ammunition.

Between March 21 and November 11, 1918, the waste of small-arm ammunition on both sides must have been stupendous, much of it flung away and never recovered by friend or foe. Centuries hence the soil and subsoil of France and Flanders will be full of rifle cartridges, long after the greater ammunition has disappeared. The rifle cartridge in a modern war is distributed and squandered with something of the lavishness with which Nature strews the seeds of the grasses.

Kynochs had been specialising in rifle cartridges as well as in cordite and lyddite, and in shrapnel since about the beginning of the century. They were the largest British manufacturers of cartridges during the Boer war, producing then about two millions a week ; and at the outbreak of war in 1914 they wisely decided to concentrate on cartridges and cordite chiefly. The rifle cartridge, unlike the rifle itself, looks a simple piece of work, nevertheless 102 distinct operations are involved in it. Nor is cordite easily produced. It has to pass through 32 processes which must be tested by a highly trained chemical staff.

The firm held decided views as to the retention of men fit for military service. A certain number could not be dispensed with. The war showed that no nation in arms, neither France at the period when she most urgently needed fighting men, nor any other, can strip clean its munition factories of serviceable men. We had that lesson impressed on us at an early stage owing to unscientific and haphazard recruiting. But Kynochs kept down the serviceable fighting men in their factories to the smallest possible number. After the schedule of protected occupations was issued, they never appealed for the retention of

their men. Despite the fact that two-fifths of their men were skilled hands they had not more than 250 of Grade I. in their factories in October 1918. A large proportion of the workers consisted of discharged soldiers and sailors, and of men rejected medically for military service. An admirable record!

The comfort and well-being of the workers at Birmingham were well studied during the war. There was a welfare department for the girls, administered by superintendents who were in the factory at all hours; there were rest and ambulance rooms and canteens for all, and a home farm. The workers at Kynochs themselves started a hospital for wounded soldiers, and by the close of the war had subscribed £40,000 towards its maintenance. The earnings of these workers showed a great increase if we compare 1913 with 1918; but, taking averages, it will be seen that the stories as to munition makers securing extravagant profits out of their work are not borne out by small-arms ammunition figures. The table below proves the wage to have been a good, progressive one, rising as the cost of living outside the factories rose. It does not suggest profiteering by the employed:

1st week in October	1913	1914	1915	1916	1917	1918
Men and Boys . .	1,029	1,543	4,847	5,599	4,830	4,903
Women and Girls . .	1,022	1,867	5,951	9,836	7,359	8,964
Total Workers . .	2,051	3,410	10,798	15,435	12,189	13,867
Average Hours worked .	49	70	68	60	55	55
Average earnings:						
Men and Boys . .	29/10	42/2	65/1	60/5	70/1	84/6
Women and Girls . .	10/4	15/11	19/1	25/4	34/10	44/6

And if the employed did not make excessive profits, what of the employer, it may be asked—must not the Company itself have taken a great fortune out of the

nation? The figures do not bear out any such suspicions. True, Kynochs sold, during the four years ending March 1918, including output of their factories in Ireland, Essex, and Natal, over fifty-five million pounds' worth of ammunition. But, after paying the Excess Profit Duty and the Income Tax, the net profit over was about $1\frac{1}{2}$ per cent on the sales. Owing to the immense scale on which these war goods had to be manufactured at the nation's call, it was possible to distribute an average of 15 per cent on the ordinary shares. Yet, if we take the last ten years of ammunition making at these works, the return on these shares is under 7 per cent per annum. Evidently the profits of armament production can be overstated. There are more lucrative investments for speculators—as well as for nations.

To turn from small arms at Kynochs to the manufacture of 18″ armour-piercing shell at Hadfields in Sheffield, gives an extraordinary contrast in munitions. At the close of the war, Hecla, the works of this firm, covered 225 acres, 61 being occupied by buildings. Hecla was employing during the war about 15,000 workers. It had plant to produce 200,000 tons of steel a year; between 200 and 300 heating furnaces; 80 presses, some of them with a 2000-tons capacity; and over 20 miles of railway, broad and narrow gauge. Hadfields' line was not so much repetition work, producing shell, high-explosive or shrapnel, by the million, as working on huge forms of munition from the crude material upwards, and sending them out as finished goods of war. They started from the blast furnace, and a great proportion of their munitions was cast in a mighty mould.

They did not procure the steel and machine it;

they made the steel and machined it. The most signal product at Hecla was armour-piercing shell of the largest calibres—12″, 13·5″, 14″, 15″, and 18″.

The 18″ was fired from a gun[1] which weighed about 150 tons with a range of 30 miles, and even at that range could pierce ordinary steel a foot thick. The Colossus of the war, it weighed 1½ tons, left the gun with 150,000 tons of energy, and at 15 miles could perforate hand-faced armour 16½ inches thick. In fact, the biggest guns in the war were not German, they were British, for use especially on our monitors. The problem of hardening the shell for this gun was solved by Hadfields. The steel had, by quenching suddenly, to be converted from a comparatively plastic state to a condition of rigidity so extreme, that the product would readily scratch glass as a diamond does. That gave the vast projectile its power to crash through and crumple up the most perfect armour in the world as though it were card-board. The 18″ shell was one of the curiosities of the war. It looks like the *reductio ad absurdum* of ingenuity in projectiles; and it is a question whether the limit in size, and even in hardness of material, for gun fire is not here reached. But the 18″ is not to be regarded as a curiosity only. The shell was an actual weapon of war: and it was supplied in considerable numbers to the Navy.

From the Hecla works 3½ million shells went out to the Army and Navy. Not a solitary gun or howitzer gun had been made there before the war, or in its early stages, but in March 1917, at the call of the Government, Hadfields quickly organised themselves for gun-making. They turned out, during the next

[1] The 18″ gun made by Armstrong Whitworth.

year and a half, 250 complete guns and howitzers up to 8″ calibre, and 3400 6″ trench howitzers, beside relining other guns. The trench howitzers are worth special notice. The Trench Warfare Department of the Ministry of Munitions had been disappointed in its plans for the production of a medium trench howitzer, as the original pattern proved unsuitable. A new design was decided on, and in February 1917 Hadfields were asked to supply a thousand by May in view of the spring offensive. This meant plunging at once into an entirely new class of work, and dispensing with preliminary experiment. Labour difficulties in May checked the work, yet the first thousand barrels of the 6″ trench howitzer were completed by the end of June. The new weapon proved a distinct success.

Besides the Hecla works, Hadfields managed one of the National Factories for the Government, staffing it entirely with their own people. This factory produced over 4000 9·2″ shells a week within a year of the original instruction from the Ministry, and later, made and repaired 60-pounder new pattern guns. The difference in cost between the 9·2″ brought from America and the same shell made in this National Factory within the Hecla Works was large. Hadfields were able to economise for the nation, thanks to the whole concern being, as it were, under the same roof.

"Now shall I know whether my officers love me by putting on their armour," says Captain Dugald Dalgetty in *A Legend of Montrose*. It was Hadfields who mainly supplied this armour in the war. I remember talking at Fins one day to a Middlesex lad in a trainload of men who had been

wounded in the fighting on the previous day, when the Guards and other regiments had come up to press back the German counter-offensive to the south of Cambrai. He had been lightly wounded by shrapnel or a fragment of shell—two entirely different missiles, though often confused in conversation and print—which had struck the edge of his helmet. The missile had made a gash in the helmet, broken its force, and as a result the soldier escaped with his life. Tens of thousands of instances of this kind must have occurred through 1916, 1917, and 1918. There is no doubt that, had we started with even an indifferent helmet, many lives would have been saved in 1914 and 1915, In all the earlier battles and raids British soldiers fought without the least protection for their heads. The French helmet was not such a good one as the British in the later years of the war, the German was quite inferior. Yet both must have saved lives and scalp wounds.

To provide helmets for British troops, it was necessary to overcome prejudice, ridicule — and bravery. The prejudice was due partly to the fact that the early helmets were not scientifically thought out, and were made of bad material; partly to the objection that to increase the weight of the soldier's kit was to increase his dangers and reduce his efficiency in attack. There was something in both objections; and a collection of the early helmets would show a great deal of thoroughly bad work, and worse steel. But by the time the Battle of the Somme was fought in 1916, prejudice had disappeared, for we then had the best helmet of any army in the field. Of course many helmets during the struggle on the Somme, and in later battles, were pierced and torn to pieces like

cardboard. Out of a pit of battle debris in September 1916, I selected and brought back a helmet, one of many in that terrible heap which had not saved its wearer. It shows an oblong hole through the crown nearly two inches long, curiously neat, sharply defined. The fragment of shell or bullet had driven home ; but, when we consider its tremendous velocity, no reproach can be made against the helmet. That velocity was probably not less than 750 feet in a second, or a mile in seven seconds : and of course it may have had a far higher velocity. Such figures are not guess-work. They are based on a series of exact experiments.

During the war, between seven and eight million helmets were turned out for the British armies. The greater portion were made out of the manganese steel which was devised and applied by Sir Robert Hadfield himself. Hadfields melted some 630,000 tons of material for steel products during the whole war ; and, of this, 70,000 tons were used for helmets and body-guards alone. For life-saving purposes, they produced nothing among their various munitions so beneficent as this head-guard of steel. Their first helmets were made early in 1916. In some instances they supplied the material in the form of steel sheets, but most of it issued from their works as stamped helmets fitted as headgear and ready for use. Our Allies ought all to have availed themselves of it. The helmet made from Hadfield's manganese or resista steel weighed 25½ ounces, about two ounces more than an ordinary French helmet and about twelve ounces less than the German. Put to exact tests, it was found that this British helmet would always keep out shrapnel bullets having a velocity of 750 foot-seconds, and frequently shrapnel bullets with a velocity of

900 foot-seconds—a mile in under six seconds. The German helmet put to similar tests was found altogether inferior. Not only was it pierced by bullets travelling at far less velocity—though the helmet was thicker as well as heavier than the British—but it was liable to crack and break up under fire where ours would only be dented.

The Germans encouraged science and invention, throughout the war, notably in the iron and steel industries, but they could not produce a helmet so good as ours. They had not, for one thing, the manganese steel armour for the purpose.

The first feeling on putting on a British steel helmet was discomfort, the weight appearing almost intolerable. I recall putting one on at Contalmaison in 1916, and being so discouraged on a road lately shell-riddled that I took it off in a few minutes and carried it for the rest of a short journey. But that feeling soon wears off; and after a while a helmet grows almost as comfortable as a cap. It can be tolerated like a set of well-made teeth, and in warm places is even more necessary for the health.

When the production of helmets was taken up scientifically, other improvements besides the chief one of material were elaborated. The shape of the steel casque was fixed—somewhat that of a deep soup plate—and a padding composed of leather, felt, and rubber studs was given to it: designed not only for comfort, but also for additional security. It helped to protect the wearer from the shock of the blow in the case of bullets and fragments of shell striking but not passing clean through.

Finally, the outside of the British helmet was treated by sand in order to prevent its reflecting light

from sun or moon which would be noticeable to keen enemy observers. It is possible to exaggerate the advantages of protective coloration and of camouflage both in land and sea warfare. The theory has become an obsession among many naturalists in their detailed observations as to the colours of birds and beasts, and particularly of insects, exactly suiting their environment. Experience in field natural history convinces one that often these colours do not protect, and that on the other hand often the need for protection does not exist. But there is no doubt that the treatment of the helmet in this matter was necessary and well thought out.

From the same kind of manganese steel used for the British helmet, a light guard for the vital part of the body was made by Hadfields, for snipers and other men engaged constantly in perilous work. About 50,000 sets of this body armour were supplied. Weight becomes a more formidable difficulty when we try to protect the body as well as the head. Body armour was by no means unknown in the war. Both sides in some degree used it. I picked up and slipped over my shoulder, a suit of body armour protecting chest and back, which I found in a recently deserted German trench in the Hindenburg line. Though excellent in design, it was intolerably heavy and cumbersome to carry on the person. The most heroic of Dugald Dalgetty's feats has struck me as his flight, *impeditus*, with the Highlander in Scott's story. Thigh-pieces, gauntlets, helmet, corselets, back-piece, he wore them complete—but, after all, was wounded because his taslets were not bullet proof. But we did not get quite back to Dugald Dalgetty's form in the war. We began to take some of his precautions,

but had not gone very far when the Armistice arrived. Body armour was in its infancy at the close of the war; but it is capable of being improved and put to invaluable service in saving life. There was this odd paradox about the struggle on land in 1914–18: on the one hand, by scientific achievement in chemistry and metallurgy, we advanced to methods of warfare undreamt of by our ancestors; on the other hand, we reverted to methods, to arms and armour which had grown old-fashioned and obsolete long before Blenheim.

Vigilant attention to science was one of the chief secrets of success at the Hecla works during the struggle. Perhaps it was the chief secret. Sir Robert Hadfield was himself a leader of science in all that relates to steel, long before the war. He invented manganese steel so far back as 1882. He and his staff were always experimenting, inventing. They have patented upwards of four hundred inventions in metal.

A feature of the work of the big armament firms throughout the war was the variety of their output. Like Woolwich, though with one or two exceptions on a much lesser scale, they were shops of all wares. There was variety of output, increasing as the war went on, in large factories all over the country which entered into the munition movement in 1915 and 1916, and acquired a facility hitherto unknown; but to nothing like the same extent as in the armament firms. Vickers, for example, with branches at Sheffield, Erith, Crayford, Barrow, and Ipswich, produced a great variety of munitions in bulk. Browns at Glasgow were making ships of war in one of their yards, and not far away they were making optical

instruments, dealing with equal facility in the mighty and in the minute—minuter measurements than those relating to optical glass work can hardly be imagined. It is impossible in a sketch of the armament firms to touch on more than a small selection of their munitions.

Cammell Laird of Birkenhead, like the other firms, delivered material of diverse kinds to the forces, but their efficiency in munition work may be illustrated by their management of a single branch, the National Ordnance Factory at Nottingham. They were asked in July 1915 to build, equip, and manage this factory, and it was started in August with a view purely to shell production. As built and equipped for shell, it included 13½ acres, 10½ acres of which were covered by shops, and cost £931,500. The programme was for a factory which would make 2000 9·2″ shell, and 6000 6″ shell a week. But presently the output reached 5000 of the first, and 6000 of the second; whilst at the end of March 1918, during the German offensive, 6250 6″ shells a week were produced, though at that period the original plant had actually been reduced by two-thirds. Here is an illustration of our progress in engineering skill and in organisation. Such figures show that, after three years of intense labour, we were far from being spent in ingenuity and effort. I doubt whether March 1918 or November 1918, had the struggle continued, would have proved our zenith—1919, even 1920, might have been still more productive. The Germans recognised after July 1918 that it would be impossible for them ultimately to withstand the mass of fresh manhood America was pouring in; but the continuous growth of British munitions must equally have filled their

organisers with a sense of despair. Here was an extraordinary fact—the more men we recruited for our fighting forces, the vaster the quantity and the surer the quality of the munitions we made for those forces. There were speakers and writers in 1916 and 1917 who insisted that if we drew more men out of industry and put them into the Army, we should starve the munition movement, and also produce less food. The argument appeared sound. But obviously it had a bad flaw, for we continued to recruit the men for military service; yet we produced more munitions than ever, more food than ever. The explanation is in the fact that we were organising our man and woman power much better, whilst our engineering skill was continuously growing.

It is worth examining in some detail the diary of this Cammell Laird factory at Nottingham to see how it faced the difficulties of changing from one kind of shell to another, and next from shell to gun making. The first sod was cut on August 15, 1915. Shells began to be produced in May 1916. By July 1916 the contract weekly output of 2000 9·2″ was reached, and by September 23 the full contract of 8000 9·2″ and 6″ combined was reached. Thus it took just over a year to get into full working order, and this, roughly, was the usual record. But after the lay-out and tools had been arranged for a 6″ shell known as Mark IV., Cammell Laird were told that a bottled shell named Mark III. was to be produced instead. Therefore a fresh arrangement had to be made, which meant extra work and delay. All through the war changes of a similar character were sprung on manufacturers. It is the fashion to attribute them to muddle and indecision in the authorities.

I doubt whether the charge is justified. In some cases it may have been, but the majority of these awkward alterations were probably unavoidable ; the war and the fluctuating character of the fighting were often alone to blame. Every great war is full of the unforeseen and the unavoidable. It always has been so, was so in the past struggle, always will be.

The chances of cricket are nothing compared with the chances of war. If another great trench war afflicts the earth we shall have the same phenomena —the weapons will be constantly changing, and no human skill will be able to provide well beforehand the form of munition required.

After eight months of shell-making for the British Army and for the Italian, Cammell Laird were instructed in March 1917 to divert part of their energies to gun repair, and next month they learnt that, besides, they were to make new 18-pounder guns at the rate of twenty a week. But on June 20 came a fresh instruction that the factory would be required for the Mark XIX. 6″ gun. So, whilst still producing 6″ shells and working on new 18-pounder guns, they had to dismantle parts of the factory and prepare for the new weapon. After many delays and disappointments owing to shortages of material and the difficulty of procuring the 350 machines needed for the new work, the first 6″ gun was finished and despatched on September 21, 1918. During the long interval between the order to prepare to make the new gun and the completion of the first a great deal of other work was going forward, but these dates —June 20, 1917 and September 21, 1918—indicate very clearly what it means even in a completed and

exactly organised shell factory to change to guns. All the floors had to be remade, the concrete deepened in order to get good foundations for the 6″ gun machines. After that, whilst the factory was waiting for its full plant, shell-making and repair work had gradually to be slackened. Yet, as new foundations were being prepared and the gun pits excavated, miscellaneous work was going on in the factory for other manufacturers: gun jackets were being made for Vickers, and tubes were being machined for the same firm; breech rings and breech bushes were being completed and fitted; 18-pounder guns were still being made, and numbers of worn guns repaired, as well as 9·2″ howitzers, in the summer of 1918.

The factory lived, and had to produce ceaselessly, in a state of transition.

Altogether not far short of a million shells for Great Britain and Italy were turned out at this Nottingham factory. No profits or remuneration were taken by the firm, and the capital cost of the factory, as equipped for shell—between nine hundred thousand and a million pounds—was paid for out of profits made on shell production; the average cost of the manufacture of the 9·2″ shell in this factory being £7 : 15 : 10 as against the Ministry's standard price of £10 : 7 : 6, and of the 6″ shell £2 : 15 : 11 as against the Ministry's standard price of £3 : 8 : 6.

Political economists are right in saying that money and labour spent on munitions of war are unproductive; yet in the light of these figures it is clear the nation did a good stroke of business when it ordered the building of the National Factory at Nottingham; for the factory paid its way.

Even when you have your floors and plant com-

plete, an unfailing supply of the material at hand, and the whole in full-going order, the making of a field or heavy gun is a highly complicated task. It may not be so complex as the making of a rifle, but the difficulties are formidable even when skilled hands alone are concerned. A good idea of the work done in this factory during the manufacturing of the new gun is given by some notes entitled "From Shell to Gun" in the *Sheffield Daily Telegraph*: "The particular gun made there now consists of two steel tubes, miles of ribbon wire, and a jacket. The tubes are known as the outer 'A' and the inner 'A.' . . . From waggons brought to the siding are unloaded . . . outer 'A' tubes in their rough forged state, which are placed in position at once on long bedded lathes. The exteriors are to be turned and the interiors taper bored, and as the tubes pass through the various processes they move onward to the top end of the bays. The inner 'A' tubes are unloaded . . . and passed onwards to lathes, the operation in this case being taper turning and boring. And here a notable exception to ordinary standardised work occurs, for the outer and inner tubes must be mated, made in definite pairs, the one for the other. Any inner tube will not fit into any outer tube, even though to the ordinary eye they are all of precisely the same dimensions. In boring the outer tube, minute irregularities of surface occur and these have to be carefully ascertained by gauge tests and charted. The chart of an outer tube boring is then taken to a definite inner tube in the process of being tapered down, and the turner working to the chart reproduces on the surface of the tube every inequality or detail in the boring of the outer tube." Standardisation is invaluable

for munition and ship making, but here obviously is something quite past its powers.

"At the top end of the bays the two finished tubes meet and are built together. The outer tube is first lowered perpendicularly, breech-end upward, into a gun-pit about 32 feet deep, then the inner tube is brought by an overhead crane, placed in position and driven home by a falling weight." The tubes thus built together pass on to other bays where the wire seat is machined. Twenty-four layers of wire are wound on—or $6\frac{1}{2}$ miles of fine steel.

Such are a few of the processes involved in building up a complete gun. A great deal of the work we now recognise can be done by women quite as well as by men. They can do final turning operations on the tubes, can handle gauges and micrometers which formerly pertained only to the skilled men. At Nottingham women made all the breech bushes and rings for the 6″ gun.

But when it comes to the turning out of a complete new gun, we have to look to the armament firm or to the national arsenal. There comes a point in munition-making when the professional armourer has to be called in; and the gun complete, like the rifle, is still his own province. The 6″ gun, for example, called for a meticulous accuracy in the complex processes of its making. There is a peculiar and oppressive sense of responsibility about the making of a modern gun, with the tremendous work put upon its driving action, which can only be met by the hard-bitten professional.

. . . . . .

The armament firms' sphere was not restricted to the production of munitions in bulk at their own

works. For instance, they lent their experts and organisers to the Government. Colonel Symon was lent by Vickers, Sir Glynn West by Armstrongs, Sir Charles Ellis by John Brown. Again, they outlined and organised large munition efforts outside their own factories. A good example was the scheme carried out by Vickers for sub-contracting the new 6″ howitzer carriages in the Manchester district. Vickers produced a vast bulk of munitions during the war, their works spreading to the South of England as well as the North, but this scheme, if one of their lesser activities, is worth mentioning in some detail for the hard thinking it implied.

Their organisation might be divided under seven heads: (1) apportionment of the work among the various non-armament firms to be brought in; (2) Contracting; (3) Drawings, information, and correspondence; (4) Raw material; (5) Patterns, jigs, and gauges; (6) Supervision; (7) Inspection.

(1) *Apportionment.*—Vickers' plan was to divide the whole work of the 6″ howitzer and its carriage into three parts: (*a*) The gun and its mechanism; (*b*) the gun sights; (*c*) the carriage. And the carriage itself they further divided into three parts: (i.) Built-up plate work—*i.e.* forgings, castings, stampings, etc.; (ii.) accurately machined heavy forgings, consisting of heavy boring, planing, and milling work for which special tackle would be required; (iii.) light and accurate machine work.

Then the method was to place orders for these different descriptions of work with, as far as possible, firms specially qualified through machinery and labour to undertake them. Vickers themselves undertook the gun and its mechanism. The sights were placed

with firms accustomed to accurate work, such as various instrument makers. The plate work went to locomotive builders, etc. The work of assembling the completed carriages was given to the firm who had built up the plate work, the other firms delivering to it their units for erection.

Turning from the apportionment of the work to the fifth head, one finds Vickers laying from the outset stress on the great importance of working up a supply of the necessary jigs and gauges for the new gun and carriage work, which could not be manufactured in less than three or four months. A spirit of co-operation was encouraged among the firms; so that, instead of every firm having to make a complete set of new jigs, etc., one firm undertook the manufacture of three or four sets of a particular form of jig, and in return received jigs from other makers in the group. Thus time and labour were economised. In place of competition—co-operation.

As to material, the arrangement was that every manufacturer in the scheme should procure his own, which had to be in accordance with the specifications laid down in the drawings; but when manufacturers failed to secure the material themselves, Vickers obtained it for them.

On the work starting, the first details to be made were the various small parts: thus the machines were cleared, largely, for the heavy material which came later when the jigs and gauges were completed. Some of these small parts, such as screws, were deliberately made in excess of requirements and put in stock: when such parts were needed they were drawn out, and clerical work and confusion were thus avoided.

All means were taken in this scheme to ensure interchangeability of details, to reduce to a minimum the labour and time spent in erection.

Vickers was such a university of arms that one hesitates to give even a general sketch of its contributions. But I must mention its machine-gun. The Vickers gun, popularly known as the Maxim, was invaluable to us. To appreciate the military worth of this weapon, it must always be remembered that the rifle-calibre machine-gun is capable of firing bullets at the rate of 600 per minute, and has even been arranged to fire 1200 per minute for aircraft use. The weight is 32 lbs. In principle the gun is very similar to the early Maxim model, but improved and lightened. The system is known as the barrel-recoiling type in contra-distinction to the gas-operated weapon. In the Vickers system the cartridge is positively controlled from the moment it enters the feed box to the time of the ejection, and it is this feature that makes the gun so trustworthy and free from jambs. The energy of recoil is utilised to function the lock mechanism, which is arranged to travel backwards and forwards in the gun casing. The lock is given a movement which effects the extraction of the cartridge from the belt and its insertion into the barrel chamber, an action which occurs during each recoil movement of the barrel upon the discharge of each cartridge after firing; and this occurs if desired at the rate of 600 per minute, so that the lock travels at a speed of 350 feet per minute. Owing to the high temperature of the propelling gases the barrel, to be kept cool, has to be surrounded with water, otherwise the weapon would be out of action after a comparatively few

rounds. The gun used for aircraft was not supplied with water, as it was found that the impinging air was enough when directed on the barrel to keep it cool.

In the early model (1901) the weight of the gun was 60 lbs., but considerable research was undertaken and as a result the present gun weighs only 32 lbs. To accomplish this the gun was re-designed and many experiments conducted to obtain the necessary data for producing the trustworthy gun now in use. This work was carried on without encouragement, as the British Government did not realise the potentiality of such a weapon. Luckily Vickers were not easily discouraged; they gradually increased their output until up to and over 1000 guns per week. In all they delivered over 100,000 machine-guns during the war.

The Vickers machine-gun was put from time to time to trials of long duration to test the efficiency of the mechanism under the severest of conditions. Long series of rounds were fired, from 2000 to 9000 a day for a period of thirteen days, during which time 51,748 rounds were discharged—30,378 of which were shot from one barrel. For these official trials the gun casing was purposely fouled with clotted ore or dry sand; the ammunition belt was also treated with a fouling matter of oil and water, so that certain deterrents could be brought into the trials which were likely to be met with under war conditions. The war proved a long and enduring trial to the Vickers machine-gun, and many letters from the Front testified to its enduring powers. Here, for instance, is an extract from a letter received from a machine-gun N.C.O. of the Australian Forces in France 1916:

> We have just come through . . . eight days, in a very warm place, but our bombers and gunners were too much for the Germans. We have been highly commended for putting a machine-gun barrage behind the village. . . . Fourteen guns were fired continuously for seven hours with only a few minor stops—expenditure, 201,000 rounds, and not even a spring broken. The Brigade captured 17 guns.

Often the Vickers gun fired as many as 60,000 rounds per day, sometimes 10,000 rounds in an hour without a jamb or stoppage that could not be corrected instantly. The gun was manufactured so accurately that any part could be taken from one gun and placed in another without efficiency being lessened.

Guns not fitted with a water-cooling device cannot fire long series of rounds without stopping for a change of barrel after each 500 rounds; thus the water-cooled gun is adaptable to all classes of warfare whether on land or in the air. When used as an air-service gun, the water jacket is used without water, being provided instead with louvres, for the passage of cooling air. This constitutes a feature of importance, since the conversion of a "land-service" gun to that of an "air-service" involves very little change.

CHAPTER V

GUNS AND AMMUNITION

When the munitions crusade started in 1915 the public soon realised that we were terribly short of shells and guns: it did not stop to inquire what perils faced us through dearth—and in some cases complete absence—of other forms of munitions. Lord Roberts's call for field-glasses having been answered, it assumed that we were secure as regards optical instruments! Nor was the absence of a British magneto industry commented on: whilst our dearth of gauges—and the defective quality of a large percentage of those we possessed—was not recognised; though, without dead-true gauges, shells and guns can certainly not be manufactured with safety to those who fire them. There were many other kinds of munitions of war, military and naval, we almost desperately needed in the early summer of 1915. Nothing was generally known or said about them. The nation's thoughts were fixed on shells and guns. That to the public was the munition question; though later, aeroplanes and tanks claimed attention, and as curiosities, the trench mortar kind.[1]

[1] Total output of guns and howitzers during the war:

New guns	25,031
Repaired and converted	9,263
From U.S.A.	1,396
Grand Total	35,690

Actually, the want of guns and ammunition was but one side of the danger. Our difficulties over other less advertised kinds of munitions had become extremely menacing by 1915. Battles cannot be fought with guns and ammunition alone. Many are the accessories required in modern war—and these we lacked.

Yet the public, limiting its survey to guns and shells, had seized upon the mightiest essential. When the last word has been said about modern battles being fought with aeroplanes, tanks, gas attacks, smoke screens, etc., it remains that, incomparably, the most important thing is the *shooting*. It was because the Germans in this had a firm grasp of the obvious that they were so formidable at the outset. The number and weight of their guns and howitzers, the abundance of their ammunition: herein lay their chief strength in 1914 and 1915; far more than in their talented generalship, or even in the minute care with which they had organised their war machine all round.

One branch of war no intelligent critic can say we had neglected—the rifle. Our Lee-Enfield was a first-class weapon, we had studied well its use, our ammunition for it was satisfactory. But speedily we discovered even in this that we must buy lavishly abroad and manufacture at home on a prodigious scale. During the war, irrespective of the supply from the United States, we produced 3,954,000 new rifles and 240,000 machine-guns—Vickers, Hotchkiss, and Lewis. And what of the ammunition for these small arms? Figures of total munition output between 1914 and 1918 might be divided into two categories: the first comprehensible, the second too

huge to convey much meaning. Two or three thousand tanks may be visualised—at least imagined; though after one has witnessed the various processes on the hull of a single tank building, or the assembly at a tank park, it is not easy to understand how a nation in the midst of a devastating war can settle down to make thousands of them in a year—and we were preparing in 1918 to do that. A quarter of a million machine-guns and four million rifles spread over three or four years are also understandable. But when the mind tries to grapple with the total figures of ammunition for those weapons it is baffled. It is in the realms of the infinite. The aggregate output of rounds of small-arms ammunition by Britain during the war can be put in round numbers at 10,000,000,000. That looks more like a calculation in astronomy than in industry.

Turning from small-arms ammunition to gun ammunition, we reach a kind of penumbral zone of war production between finite and infinite. Total ammunition statistics are approximations. They have not been religiously verified like those of guns. But the number of empty shells for guns and howitzers —trench mortar ammunition excluded—which the nation had to find before it reached victory was over 250,000,000; of filled shells over 200,000,000.

When at length in 1916 our new national factories had been built and were in running order, and the commercial factories had been converted into arsenals, shell-making for the Army became one of the simpler propositions in munition work. The build of the shell in many cases was somewhat simplified to increase and speed up output, the curved outline familiar in the greater naval gun projectile giving

place to a straight one which required less hand refining. Repetition work reached a state of precise perfection in these highly organised factories. Clockwork method was instituted; and the clock went true to the second. Among the shell factories I visited in 1917 and 1918 I may cite the National Projectile Factory at Cardonald, managed by Beardmore, the armament firm at Dalmuir and Parkhead, Glasgow, as an example. It took the usual period, a year or thereabouts, to build and equip. Once fairly going, it produced with the regularity of an automatic machine making screws. But in the management of these factories a great deal more than automatic routine was called for as the war developed. Emergencies occurred when plant and organisation had swiftly to be changed from one kind of shell to another. Such conversions could not be foreseen, and without quick intelligence and goodwill among organisers and workers they would have disastrously retarded output.

When I visited Cardonald it was in part being changed over from an 8″ high-explosive to a 6″ cast-iron chemical or lethal shell. It had about 4000 workers, the majority being women. The number of men of military age and physique was limited to 30 skilled engineers or mechanics. The work was proceeding with that absence of fluster and overlapping which was so noticeable in munition areas later in the war. The whole business of war production had taken charge; was moving irresistibly by its own momentum, carrying all in front of it. Strikes, disputes, sudden conversions from one form of munition to another, destruction even of our transports carrying material of war, none of these could

dam the flow of output. As for pacifism—where it existed—that was swept away as a straw before a gale.

Foch in one of his speeches spoke of the Allied offensive after August 1918 as an inclined plane when once the retreat of the enemy had become general. The figure might be applied to our munition movement in its later period. We were alarmed by the strike of the A.S.E. in the North, by the Coventry strike, but see now they were straws, had no more power to arrest the flow of munitions at the Base than the German machine-gunners after the Battle of Amiens had to stop the onrush of the Allied armies through France and Flanders.

The National Projectile Factory at Cardonald was in that phase when I spent a day there in 1918. It was turning out the 8″ and the 6″ shells. They were delivered at the factory not in the form of the billet, but after being cast in the first rough mould, and then with the steel pierced or forged hydraulically into the hollow cylinder form.

Shell-making, compared with many other kinds of munition, looks easy, yet even when the shells reached this factory after the first processes they had to pass through some five-and-twenty distinct stages and tests. The 6″ gas shell had to pass two Government and three factory inspections. The same shell, as it passed from lathe to lathe, bench to bench, had to be parted at the base end, sand-blasted, faced for centring, centred, rough-turned, bored, cut to length, weighed, cut to weight, grooved and waved, copper banded ; it had to be drilled with a small hole at the side for filling, fitted with its nose bush, weighed again, air-tested. The 8″ high-

explosive shell passed through about the same number of processes, some identical, others slightly different from, or additional to those of the gas shell. Throughout these processes the shells, 6″, 8″, 9·2″, 12″, 15″, in fact all calibres, had constantly to be gauged; and the gauge itself had to be closely examined and tested by engineers in the tool-room.

In every great projectile and shell factory, from 1916 onwards, one was struck by this paradox: here was the most scientific and deadly instrument of war, all technique and curious calculation, simple only compared with far more complex forms of munition; yet elaborated through every stage from rude cylinder to final coating of varnish or paint by hastily trained amateurs, mostly girls and unskilled men.

The explanation lay in the minute subdivision of labour, in the single task endlessly repeated by the same hand and head. It ran through the entire munition movement 1916, 1917, 1918. It went far to solve every problem of output, minute and immense.

Working within fine limits on a great manufacturing scale by hundreds of thousands of unskilled hands supervised by a sprinkling of skilled is one of the chief discoveries of the war. Some people see in it *the* discovery. Through this discovery the world is destined to enter a new era of industry. The thing may bring with it certain ills. It threatens a grinding monotony, but it promises an immense addition to output; an economy of effort; a better article. I may return to the subject in treating of the achievement of labour in the war. Incidentally, one is bound to refer to it no matter what the form of munition discussed may be. It became universal in the engineering and chemical manufactories; it revolu-

tionised the industrial system. There may be a reaction against it through labour fears and prejudices, but it is as sure to prevail as were steam and electricity.

The single task in these projectile and other factories, repeating itself like a decimal fraction, seemed to leave no scope for initiative in the unit, to reduce all effort and intelligence to the same dimensions. Yet there was room for exceptional achievement in output, on rarer occasions for exceptional devotion. As to the first, I have a note about a girl of eighteen working on the copper band turning of some type of projectile. The record by men was 220 in a shift of nine hours. This girl ran the record up to 550 in the same shift. As to the second, factory work was far safer than any task during action at the Front; and this applies even to the handling of dangerous material for high explosives and propellants. Yet accidents happened from time to time in the munition factories. It was, I think, at Cardonald that a man working on repairs fell from the roof and broke his neck; soon afterwards another worker fell from the same place; a man of seventy rushed up, caught and held him in his arms, and by extraordinary fortune neither was hurt. There were many hundreds of cases, some recorded at the time, others obscure, of devotion and presence of mind of this character.

The notion that a munition factory was a place full of shirkers and profiteers is grossly ignorant. I never came out of a munition factory oppressed by the spirit of pessimism. The greatest place, the place for heart and hope in man, during the struggle was the Front—the trenches; dressing stations;

batteries; army, corps, division, and brigade headquarters. Next best—the munition factory.

Even in the early days of the shell scare so many organisers were doing sterling work that it seems invidious to select names. But two men have certainly to be mentioned, because they stand respectively for the two groups of shell manufacture and energy in which the industry was divided. The shells came from five sources when that industry had been scientifically organised: (1) Woolwich, (2) the Armament Firms, (3) the Projectile Factories, (4) the National Shell Factories, (5) Boards of Management Contractors.

Sir Glynn West devoted himself to Armament Firms, Projectile Factories, Woolwich; Sir James Stevenson to National Shell Factories and Boards of Management contractors. Their energies did not clash. They ran somewhat on parallel lines. There was ample room for both. Without a doubt both men, in their allied spheres, did great service for the country.

Sir James Stevenson had not the least knowledge of munitions of war, nor affected it. He was a man of business, who knew a great deal about industrial concerns, and understood the railway system of Great Britain. Mr. Lloyd George asked him to join the Ministry, and in June 1915 he came in and at once proceeded to divide the country for munition purposes into areas. He asked for a map of England; but there was no map in the office. In fact, in those primeval days there was nothing to speak of on the premises at 6 Whitehall Gardens. So he sent out a boy to buy the map, and proceeded to divide the country into Areas of Organisation, which remained

throughout the war almost as he sketched them in June 1915.

There is a story that somebody drew his attention to the fact that he had left out Herefordshire. It was not a promising field for shell output.

"Well," said the Director of Area Organisation—Stevenson's title—"that can go to the Board of Agriculture." There were prophets during the war, but none has proclaimed that he foresaw in 1915 that one of the greatest filling factories would be built near Hereford.

When Sir James Stevenson started, shells were being ordered through the local munition or armament committees in different parts of the country. The organisation had defects. Therefore, under the Ministry of Munitions, Boards of Management were started. The nucleus of the Board was the munition committee already existing. There was one Board at least to every Area, consisting of five or six members individually approved by the Minister of Munitions; and these Boards as well as the Area Organisation were Stevenson's province. Hitherto the view had prevailed that shells could not be satisfactorily produced except by the State arsenal, the regular armament firms, and certain heavy projectile factories; and that, at most, outside firms would only be able to produce the 18-pounder shell.

This was not altogether an unreasonable prejudice, considering that the country was not organised for manufacturing munitions on a great scale, and that the possibilities of unskilled labour were hardly dreamt of.

The Boards of Management started to produce

shells only, components being a later sphere, and towards the end of the war aeroplane parts. Guns, rifles, and other kinds of munitions the Boards never undertook. Nor, in shells, did they touch anything above the 9·2″. They were responsible for an immense output during the war of 18-pounder and 4·5″, with a few 13-pounder, also for an output of 6″ and 8″ shell. The greater projectiles for Army and Navy were outside their field. Nor were they concerned with shell-filling factories, which at first Sir Eric Geddes and later General Milman was controlling.

The Boards watched over three lines of shell production when the new munition organisation began. First, there were the National Shell Factories; second, co-operative production, which was chiefly practised in the West of England; third, the Boards devoted themselves to placing contracts and supervising output as agents for the Ministry of Munitions. They were middlemen between the State and the contractor—only they were not paid for their services, which were invariably given free. The idea that the munition movement was compact of profiteers and jobbing is a grotesque delusion. I doubt whether during the war propaganda itself spread a falser story. Passed recklessly from fool to fool, it has already worked a world of mischief at home. It has played into the hands of those whose design is to discredit our social and political system, and bring down the whole in ruin. Only discredit the munition movement, spread the rumour that money-making and corruption were behind it all, and what a lever is in the grasp of the revolutionist! Additionally, our whole cause in the war stands condemned!

The work of the Boards of Management is a capital example of disinterested service. Not only did the members of the Boards work without pay, the costs of management were defrayed out of contributions from the contractors. That is, a deduction was made from the contract and set aside to pay the working expenses of the Boards of Management. The sum was only a quarter of 1 per cent, yet so great was the output that this fraction was ample for the purpose. In the autumn of 1919 a statement appeared in the press that the Manchester and District Armaments Committee—one of the bodies out of which the Boards of Management sprang as executive authorities—after defraying all expenses and winding up, had a surplus asset of £16,000, which was to be spent during the next ten years on scholarships for boys showing promise in engineering. This sum was the residue of the quarter of 1 per cent deduction from contracts through the war.

But the Boards not only economised scrupulously in these small matters. They were helpful in the far greater work of reducing the price of output as the war developed. They helped to bring down the cost of, for instance, the 18-pounder shell from its original twenty-five shillings to not less than half.[1] The costing department of the Ministry of Munitions was the main instrument by which the nation was saved money in the latter part of the war; but the Boards of Management should be given their share of credit. Unless the critic is out, openly or covertly,

[1] Obviously the price of munitions was bound to come down as the bulk grew. That is common to all forms of industry. So the reduction in the price of the 18-pounder shell is not the miracle that some people have represented it. But the reduction of price was really creditable, and it is stupid to overlook the fact.

to wreck all authority and hasten revolution, he will recognise facts like these which can be proved.

The Boards of Management succeeded. They supplied, through the National Factories and the contractors, from 20 to 25 per cent of the output of shells during the war. They were under the direction of Sir James Stevenson from the summer of 1915 to the end of the war. In September 1917 he was placed on Mr. Churchill's Council, and became responsible for projectiles; and in February 1918 Ordnance was added to his group.

Shells, still less guns, cannot be created where technical knowledge is wanting. But the supply can be speeded up and ensured by driving power united with tact in a great man of business. Such was the D.A.O.; and, fortunately, he was discovered by the first Minister of Munitions. His original map, if it exists, ought to go to the War Museum.

Sir Glynn West, like Sir Percy Girouard, was a loan to the Government from Armstrong Whitworth. Early in the spring 1915, he had formed definite, comprehensive views as to the best way to ensure the output of shells and components.

He was for a policy of "Thorough"—the State to take control forthwith of ammunition manufactories; all machinery suited to munitions to be organised; engineers to be grouped in various districts and taught how to produce munitions; the skilled labour of the whole country to be organised.

He wanted the State to take a census of the engineering firms; and to engage a staff of machinery agents who from their own experience knew exactly where the right kind of machines existed, and would be empowered to go round and earmark them. The

machines should then be concentrated in clearly defined districts, and put at the disposal of groups of firms responsible for the manufacture of shells and components. The scheme necessarily meant that many machines would have to be commandeered by the Government from small firms to make up units otherwise deficient; such firms to be paid for the machines taken and compensated for any loss of trade.[1]

He proposed to put every group under the supervision of a regular armament firm; and the chairman of the group would have to see that the directions of the supervising armament firm were duly carried out. The groups should at once be methodically instructed in munition work by foremen and skilled hands drafted for that purpose into the works of the different firms. By the time the machinery was supplied and in running order, these works would be able, he considered, to manufacture shells with something of the facility of the armament firms themselves.

The dearth of skilled labour in munition works, owing to recruiting for the Army, has been referred to more than once. It was a grave impediment to large output. But West acutely noted that there was still a considerable wealth of skilled labour engaged on lathes, etc., in the purely commercial industries. He held that his proposed groups of new munition firms could be amply fed from this source, and that, even after this, enough skilled hands would

[1] When the time came, soon afterwards, to equip the National Factories in the North and Midlands, machines—presses, lathes, borers, automatics and semi-automatics, etc., for shell-making—had to be sought high and low. The official correspondence relating to these factories in great part concerns this hunt. An enormous quantity was got together and adjusted to munition-making, and also was purchased in America. The machine tool department was strenuously worked by Sir Alfred Herbert of Coventry.

remain over to fill gaps in the firms already at work on munitions.

Early in May 1915, West's suggestions came to the notice of Army Council and Cabinet. They made a strong impression; and in June, before the creation of the Ministry of Munitions, he passed into the direct service of the Government, acting at first as a technical adviser on the equipment of shell factories then starting at Leeds, Bradford, Keighley, and Dundee.[1] Elswick was at first rather uneasy lest the transference of his services to the State should militate against its own output: he was controlling over sixteen thousand hands, great new works were developing there, and his intimate knowledge of shells and guns was invaluable to the firm. However, the firm consented, it being understood that the arrangement was temporary and could be reconsidered if necessary after three months.

Early in June, West became technical assistant to Sir Percy Girouard at the War Office; and, when the Ministry of Munitions was established, he was made Deputy-Director-General—first under Girouard and later under Sir Frederick Black—of the department of shell manufacture, which included the development of supplies from the National Factories and the organisation of production by direct contractors. In July, a further scheme for National Projectile Factories was adopted, and West became responsible for their building, equipment, and management. Also his duties included the purely technical side of the shell

[1] I have examined a great deal of the correspondence, etc., relating to the inception, building, and equipment of these factories, and have been struck by the fact that the technical adviser had day by day to go personally into all manner of details as to machinery, material, labour, etc. He was enthusiastically aided by local patriotism.

and components work of the Boards of Management.

His province did not end there; for, with the aid of Major Strange, he had to supervise the gun ammunition filling throughout the country. By the close of the year this filling became an immense undertaking, and Mr. Lloyd George transferred it to another section of Munitions Supply. Finally, he was responsible for (1) certain raw materials, Sir L. Llewelyn's branch; and (2) supply of machine tools, Sir Alfred Herbert's branch. The provision of gauges and the development of electric power supply were other items on his list.

From June 1915 onwards, West's work was well cut out for him. He was, in the original sense of the term, an ambitious man, *i.e.* a man who goes about. Probably he had no time to keep a diary, or it might appropriately be put into the War Museum with Stevenson's map; for a diary would, I think, show that sometimes he and one or two of the devoted band who strove with him had to sleep in the railway carriage four, even five, nights running. There was "a move on" in the winter of 1914, and it is crass ignorance to represent that the War Office did nothing much in munitions at that time—crass ignorance and base ingratitude. But by the autumn 1915 the pace in gun ammunition had grown tremendous. My impression is that the Minister of Munitions was right to relieve somewhat the pressure on Sir Glynn West's department by a transfer of the filling business. Even so, the work remaining with the Deputy Director of Shell Supply was immense. It did not distress him.

Two lessons of the war, taught us alike by munitions at the Base and fighting at the Front, have been

—(1) that the catch-phrase of a few years ago, "Too Old at Forty," like most of the popular catch-phrases,[1] was claptrap; and (2) that hard work keeps men bright and wholesome without necessarily wearing them out. The work in the field and the factory during those four ardent years, done even by men who had honestly believed themselves to be "crocks," was extraordinary. It re-created many men well on in middle life who were all ache and pain before August 1914. They renewed their youth like the eagle. "Dug-outs" forgot the doctor, took to beer when they could get it, and instead of "grousing" over the pain behind the shoulder, or in the lumbar regions, only "groused" if they could not get somewhere near the firing-line. It was much the same in the factories. Men there insisted they were not too old at seventy, and often resented the idea of being retired. The pessimists who go about moaning over the dreadful results of the war, and the approaching end of human civilisation, etc., forget the spirit of 1914–18; that is one reason why they are so absurdly astray. The recoveries of war are overlooked by those who are always moping over its casualties. The munitions crusade made, as well as marred, manhood. That reflection was often with one whilst moving about among the war industries of the North and Midlands.

In August 1916 Sir Glynn West's official position changed in form. He began to report direct to the Minister of Munitions, and was styled Controller of Shell Manufacture. In March 1917 he was turned on to a new urgent work, the repair of guns. By

[1] For example, "Get on or get out"; the "survival of the fittest (*i.e.* the most brutal, as applied to human civilisation); and "sack the lot.

that time the ammunition shortage had virtually ended. The problem of the shells had been solved, that of the guns threatened to succeed it. The 1915 and 1916 guns and howitzers were fast wearing out through tremendous, incessant fire, and we had not the necessary reserve of new guns to take their places. Factories built and equipped in those years solely for the manufacture of shell had to be converted in part to the manufacture and repair of guns. Whole bays in the National Factories had to be quickly dismantled. As an expert in guns, West had clearly foreseen this result of intense barrage fire. For months past he had been warning people what must occur. When Mr. Lloyd George anxiously asked him how long the shells would be in arriving, he would answer that the shells would come all right presently—but what about the guns to fire them when the tubes of those we had wore out?

In February 1918 West's direct services for the Government ended. He returned to Armstrong Whitworth. By then we had the gun ammunition we needed. The National Projectile Factories had reached and passed the output expected from them. The quality of the shell of all calibres had greatly improved, the prematures and duds of the Somme were largely disappearing, and with them had disappeared the earlier and unsatisfactory detonator.

I now turn to the wonderful story of the guns. In August 1914 we had at the Front in France four to five hundred pieces all told; in 1918, after the German offensive, which cost us 1500 guns or so, we had between six and seven thousand at the service of the Army. Let us see what steps were taken to create the artillery.

Early in the war orders had been placed by the War Office with four armament firms[1]—Armstrongs, Vickers, Beardmore, the Coventry Ordnance Works—and with Woolwich, for 18-pounder, 13-pounder, 60-pounder guns; 4·5″, 6″, 8″, 9·2″, 12″ howitzers. Altogether, these orders amounted to about 5000 guns, including 3628 18-pounders and 812 4·5″ howitzers. The Coventry Ordnance Works were to produce most of the 4·5″, Armstrongs and Vickers between them the bulk of the field-guns. More than half of the 60-pounders were ordered from Woolwich. Additionally, we sought salvation at Bethlehem, placing orders there for 250 18-pounders and 100 13-pounders. But by June 1915 it was clearly seen we needed a large supply of heavy artillery as well as field-guns; and the War Office asked for 1618 4·5″, 560 6″, 372 8″, and 48 12″ howitzers, besides a greatly increased number of 60-pounders. It fell accordingly to the gun supply department of the Ministry of Munitions, with Sir Charles Ellis as Deputy-Director-General and Colonel Symon as his assistant, to work out the new programme. To carry it through, the armament firms and Woolwich had to be authorised to build new works, and orders were given for between two and three thousand more machine tools.

Limbers and waggons were entrusted to various firms hitherto engaged in constructing railway rolling-stock. The armament firms and Woolwich sub-contracted with outside manufacturers for spare parts, etc., of gun carriages, as well as for the non-optical parts of gun sights.

[1] Great extensions to these armament firms had to be sanctioned in 1915. Approximately there was spent on Beardmore, £700,000; on Vickers, £800,000; on Armstrongs, £525,000; on C.O.W., £280,000. Further large extensions were carried out in 1916 and in 1917.

An enormous amount of preparatory and organising work had to be got through before the production of the guns and howitzers, which were largely of a novel character in this country, became satisfactory; for instance, entirely new sets of jigs and gauges had to be manufactured. It was found that no appreciable output could be secured under about nine months' or a year's time from the new machinery, whilst full output, in some instances, took a longer period.

In those days little was heard about the repair of guns, which did not become a critical question till the beginning of 1917. But in 1915 it was not overlooked by the new authority. Major M'Clymont, and after him Captain Milman and Major Morten, were entrusted with the duty of allotting to various firms the guns and carriages needing repair; whilst in 1916 a branch was established at Southampton to receive and despatch guns from the Front sent back for repair.

In July and September 1915, as results of conferences between the Ministry of Munitions and the armament firms, two large programmes for gun and howitzer production were adopted. The first included nearly 582 18-pounders (400 from Bethlehem, U.S.A.), 621 60-pounders, 637 4·5″ howitzers, 458 6″ howitzers, and 132 8″ howitzers of a new type. The second programme considerably increased that of July, and included 210 9·2″ howitzers (Vickers and Bethlehem), and 37 12″ howitzers (Armstrongs, Vickers, and Coventry).[1] It was decided upon with

[1] Besides, the Army was to take over 12 15″ howitzers which Mr. Churchill had ordered as First Lord of the Admiralty in 1914. These howitzers were delivered in 1916. They were the only howitzers of that calibre made, as the 12″ was found more satisfactory.

a view to output in the spring of 1916 when the British Army might take the offensive in France.

This additional September programme went well beyond the stated requirements of the War Office, and the Secretary of State for War protested against it! It was, however, adhered to; and, as a fact, the events of 1916 showed that we had not too many guns and howitzers for our needs, and could not meet all the demands for artillery made on us by Russia, France, Italy, and other Allies.

We supplied Russia in the spring 1916 with 300 4·5″ howitzers, and followed this up with 100 equipments and 400 waggons. For the following year we promised her 222 guns and howitzers—60-pounders; 6″, 8″, and 9·2″ howitzers—and had delivered 153 of these by May 1917. Still these Russian demands for heavy howitzers grew. In order to meet it we placed an order for 100 more 8″ with the Midvale Company of U.S.A., which began to come through in May 1917. Besides, we ordered for Russia 3500 3″ field-guns, 200 3″ mountain-guns, and a large number of spare parts and tractors for heavy howitzers. Altogether, in about a year and a half, we got together for this Ally four or five times as many guns and howitzers as we had ordered from the trade on our own account in the twelve years before August 1914!

In 1916 there followed further extensions. Verdun emphasised the value of heavy howitzers, such as 8″ and 9·2″. Accordingly, a large increase in both was decided on in the spring. In the autumn of 1916 there came a call for long range; and 6″, 9·2″, 12″, and 14″ guns were ordered from Vickers, Armstrongs, and Beardmore. Immediately afterwards, the Admiralty needed a large number of 4″ and 6″ guns

for the arming of merchant ships against submarines; and between January and December 1917 a scheme was drawn up towards the production of between seven and eight hundred 4″ guns, divided among the four armament firms—Armstrongs, Vickers, C. O.W., Beardmore—and Woolwich.

In addition, anti-aircraft artillery had to be provided in increasing quantity, and before the close of 1916 it was well understood that gun repair must become a great and urgent organisation. The great armament firms, with their sub-contractors, and Woolwich, had their hands full, even with the help of several American firms, such as the Midvale Steel Works, which Sir F. Donaldson visited and reported favourably on in 1916. To understand the extraordinary strain placed on the British gun manufacturers in 1916 and 1917, one must glance at the state of things before the war. Between 1902 and August 4, 1914, there were ordered from the trade in Great Britain, *i.e.* the great armament firms, 657 18- to 18½-pounders, 168 13-pounders, 9 4·7″, 12 60-pounders, 15 6″, 4 5″, 1 9·2″; and 96 4″ and 4·7″ howitzers.

Taking together all types, the trade was called on in those fourteen years to supply the British Government with just under 1000 guns and howitzers: or about 70 pieces a year. Such was the average. But the great bulk of the total 1000 was manufactured in 1904–5. In some years only two or three guns were ordered and made; in 1910–11 the number was 0; and between May 1 and August 4, 1914, it was 1.

The truth obviously is that the term "armament firm," so far as the British Army went, was a mis

nomer. The armament firms were not asked or expected to manufacture arms. If that had been their business they might as well have transferred their sphere of activities to the Fiji Islands or to the South Pole. We had to create in the course of the war several new industries, which before 1915 had merely been dabbled or experimented in on a laboratory scale, such as magnetos and optical glass. But, in point of fact, had we not also during the war to create, outside the Royal Ordnance Factories, the new industry of guns, howitzers, and their carriages? The figures I have quoted for the years 1902–14 point to this.

Between August 1914 and May 1917 first the War Office and then the department of the Ministry of Munitions placed orders for 17,737 guns and howitzers of all descriptions, together with a somewhat lesser number of carriages. The 18-pounders[1] formed of course by far the largest item—just under 7000—and after them the 4·5″ howitzers and the 6″ howitzers, in round figures between two and three thousand of each. Fourth on the list come the 60-pounders, and fifth the 6-pounders with which our "male" tanks were equipped.

In the autumn of 1916 the importance of repair was recognised, and arrangements were made to start in earnest on this work in the following year. So urgent must the need become, it was recognised,

[1] The estimated output of the 18-pounder was delayed considerably owing to the fact that during the war we changed from spring recuperator to air recuperator type. The improvement was great, and we ended the war with perhaps the best field-gun in existence, not excluding the French 75; but the alteration in design threw back production inevitably. Improvements in design—to secure greater range—similarly affected the production of 8″, 9·2″, and 12″ howitzers during the war. Strikes at Barrow and Sheffield put back the output, moreover, of the 9·2″ in 1917.

that repair might even have to be given priority over new construction. The life of an 18-pounder was reckoned at 12,000 rounds, a 4·5″ howitzer at 15,000, a 12″ howitzer at 4000, a 9·2″ howitzer at 3000, and a 9·2″ gun at 1000. It was estimated that in 1917 we should wear out over 3000 18-pounders, 860 4·5″ howitzers, 60 12″ howitzers, 1020 9·2″ howitzers, and so on. Therefore we must make provision for replacing these gun and howitzer casualties, besides keeping up the reserve to cover temporary deficiencies through guns and howitzers being sent home for repairs. Between the summer of 1915 and the spring of 1917 the problem of the guns was without doubt a mighty and a menacing one. There were many ardent organisers in the department during that period. If individuals are to be mentioned, the lightly advertised name of Colonel W. C. Symon must not be overlooked. He was loaned to the Government by Vickers, and proved an invaluable expert.

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Who wrought our amazing transformation in shells and guns? The straight reply is—neither Stevenson nor West nor Symon—nor all three. The service of these men is emphasised here because it was highly typical of the directive work in shell and gun. Everybody who has chosen to look into the matter knows, for instance, of the efforts and trials of the Master-General of the Ordnance, General Sir Stanley von Donop, in the impossible welter of 1914; at least has heard of General Sir F. R. Bingham, chief of Design at the War Office, then at the Ministry of Munitions; of Sir Charles Ellis, and of various other munition experts as well as men of business.

Names are satisfying in a record of war—up to a point. Beyond that they cloy. And if they are over-exploited the result is recrimination and bitter counter claims. There is another drawback, and greater, to the exploitation of this man as the hero of the tank idea or that man as the genius who first perceived that the war was going to be won by aeroplanes, or depth charges, or smoke screens, or what not; it wholly overlooks the fact that the tanks and aeroplanes and depth charges and guns and shells were actually made not by this or that individual, but by the common people, the hundreds of thousands of obscure factory hands, the privates in the ranks. THEY SUPPLIED THE GOODS. It was not an individual's "show," it was the puissant feat of a nation. The great majority of the factories fitted for war work were engaged on war work before the close; so were the great majority of the men—and certainly the best of the men—disqualified through age or physique for service at the Front.

Rivalries and personal comparisons between this reputation and that reputation are puerile in the face of a vast national achievement such as this; and unjust to the mass of the toilers. Fortunately few of the directors and inventors have thrust themselves into the limelight. The exhibition over the tanks was a deplorable exception.

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The chemist's part in the munitions crusade was tremendous and terrible. One of the reasons why it is incorrect—apart from the question of unfairness to the fighting man—to describe the war as "an engineer's war" is that this leaves the chemist out of the reckoning, the last person concerned in

munition who should be left out. The subject is most difficult. It is nothing if not highly technical and scientific; and, if treated in anything approaching fulness, it admits of no popularisation. When we attempt to go into details about a propellant or high-explosive, its composition and preparation, and the adaptation of existing forms of shells and their components to suit it, we are soon befogged, as would be a schoolboy learning the rule of three and suddenly plunged into higher mathematics. Volumes will be written presently to illustrate the work of the chemist between 1914 and 1918—and at many another place besides Gretna, which so struck on the public imagination and became the most famous British munition factory of the war. I shall try to give only a few sign-posts which may help enquirers to find the way to the great manufactories where this problem was grappled with and successfully solved. There is no question about the ultimate success of the chemist in the war. His goods were delivered. November 11, 1918, found us with an embarrassing surplus on our hands. That was one of the results of the struggle which no one dreamt of, still less prophesied, in 1914 or 1915.

The three principal features of the movement, which started in 1914 to supply the fighting forces with the prodigious mass of explosives needed, may be stated as:

(1) The use of alternative explosives.

(2) The building of new factories on a scale far greater than that of our solitary existing State factory, Waltham.

(3) The organisation of the supply of materials.

Alternatives.—The start of the war found us using

the propellant known as cordite, and the high-explosive known as lyddite (picric acid). These were the explosives of which much was heard at the time of the Boer War, and since largely forgotten. A rather widely spread idea during the shells agitation in 1915 was that the British forces were not supplied at all with high-explosive, though as a matter of fact lyddite was quite as much that as T.N.T. True, it gradually went into disuse, was displaced by T.N.T. All the same it was distinctly H.E. Before long, the great expansion in the use of high-explosive led to the adoption, first, of T.N.T. in 1914, and next of ammonium nitrate mixtures in about the middle of 1915. Similarly, when the Army called for a greater quantity of propellants, we turned to the United States for the purchase of nitro-cellulose powder, and set about the manufacture of it in Canada: also we developed and manufactured a new British cordite and in the making of this used alcohol in order to economise acetone. Our whisky, for example, had to be watered for munition purposes in more than one sense.

In resorting to these alternative explosives the problems and purposes were:

(*a*) To discover such substitute forms as would meet the exacting standards of both naval and military authorities, notably as regards stability, that is, the property of keeping on storage. Our standards are particularly exacting, because naval explosives have to be kept on shipboard often for a long period during which an accident may result in serious disaster; and because we must have forms of explosive that will remain stable in very different and trying climatic conditions. We must provide for the protection of

a world-spread Empire, where temperature greatly varies.

(*b*) To evolve designs of ammunition suitable for use with the new forms of explosive. As a simple illustration of this task, when high-explosive shells were asked for by the Army for field-guns it was necessary to supply a suitable design, as mentioned in an earlier chapter.

(*c*) To organise, immediately, the manufacture of these explosives on a gigantic scale; instead of dabbling or experimenting in them, as hitherto, on a mere laboratory scale.

Building New Factories.—Hardly had the war started before it was recognised by experts that the trade explosive works already existing were utterly inadequate to supply our forces. There was expansion of certain chemical industries in 1914–15, for instance, of the dye industry, to increase the supply of picric acid for lyddite shells, but the great pressing task before the country was to start immense new factories. We began with a T.N.T. factory at Oldbury. That was a fine and swift piece of work; the factory being planned, built, and actually at work within the space of twelve weeks in the spring 1915. Thus we now had a national factory for making cordite (Waltham), and another for high-explosive. During the same year other factories were built to supply T.N.T., at Penrhyndendraeth, on the site of some works destroyed by an explosion, and at Queensferry near the Hawarden estate. Various trade factories in addition were absorbed by the State for making T.N.T.

Great propellant factories, as well as these T.N.T. factories, were rushed into being in 1915. The Navy

set up its own propellant factory of moderate dimensions near Poole in this year. In the summer, Gretna was planned for the manufacture of the new British cordite. The enormous factory, completed, was some nine miles long by a mile broad. It was guarded by upwards of a thousand men, and policed by men and women. Bakeries to supply the population of this large new town were instituted on a scale resembling those at Calais which fed the British Army. One remembers coming past Gretna for the last time during the war in the gathering gloom of an autumn evening, and strangely impressive it was in that half light. This place, set on a turf bog, with nitric and sulphuric acid plant and great leaden basins in which the dangerous materials were handled, had a sinister, aloof air, suited to its grim business.

But though these chemical factories were planned and created simply for destructive war ends, a great deal came out of them that conduces to a nation's progress in the industry and science of peace. We were intensely concentrated on war needs throughout the chemical munitions movement, yet sub-consciously we were taking lessons in beneficent industry which Germany and other nations had learnt and applied before 1914. For instance, sulphuric acid was required in such bulk for explosives that its use had to be prohibited in various general industries. So, too, in a less degree, nitric acid ; and, as a result, we were driven to discover that a by-product, pure waste before the war, could be converted into a substitute and used with excellent effect by these otherwise starving trades. Nitrogen and its compounds are essential to explosives, but they are essential to agriculture also. Many years ago Sir William Crookes

accented the importance of opening up fresh sources for the supply of this fertiliser. He experimented in obtaining nitrogen from the air. Germany and Norway acted on his suggestion; the former establishing the famous Haber or synthetic ammonia process; whereas we contented ourselves by recovering the ammonia at gas-works and coke ovens. When the war started Germany had only to develop her established processes, and she was self-supporting. It was not until the submarine campaign grew very menacing, threatening our imported supplies of material for explosives, that we were induced to experiment for fresh sources and to develop in haste the manufacture of large supplies at home.[1]

For the 1917 campaign it was found necessary to expand still further the supply of high explosives at home, so four new picric acid factories were built. Two new propellant factories were also planned when the submarine campaign grew very formidable and imperilled our supplies of nitro-cellulose from America in 1917–18. This powder industry was wholly new to Great Britain. Eventually, it was necessary to establish only one of these factories—we had at length grown virtually self-supporting.

Organising the Supply.—The crux of the whole position in 1914 was the material supply—how to get the tremendous bulk needed. It was largely for the organisation of the country's output of coal-tar products that Lord Moulton's Committee on the Supply of High Explosives was formed in the late autumn, 1914. The War Office approached the

[1] The Nitrogen Products Committee was set up under Colonel Gould-Adams, Controller of the Munitions Invention Department in 1916. It instituted research on the production of synthetic ammonia perfected by Haber at Karlsruhe.

Board of Trade which appointed his committee, at first giving it advisory powers only. In December the committee was given executive authority under the War Office, and it started promptly to organise the production of toluol for T.N.T. manufacture, and to increase the capacity for phenol by building factories for synthetic manufacture. During the same month it mobilised the coke ovens and gas-tar producers. By the spring of 1915 the big gas businesses had been brought in, and soon afterwards the smaller works were linked up. Lord Moulton, who came in at the start and stayed till the close—a quite rare record among munition organisers—was indisputably the right man for the work. He was a chemist; he well understood the industrial and manufacturing side in regard to the essential materials for propellant and high-explosive; he had the will and driving power for the great task before him. There were many able organisers on this side of munitions whose work was invaluable. Yet Lord Moulton's name has not been proclaimed too loudly. An organiser need not be an expert in the industries he is called on to co-ordinate and mobilise for war. He can arrange successfully for the supply of goods without understanding how exactly those goods are created. Men may successfully organise the supply of guns who do not know how guns are fired, much less how manufactured. But the organiser, the organiser born or made, who has studied closely the science of the particular industry he is called on to mobilise, must have an advantage over the inexpert—other things being equal of course. Similarly, who could gravely dispute that a Cabinet Minister for Education or Ireland or the Admiralty, who scientifically had

studied and understood Education, Ireland, or ships of war, must be better for the nation than an equally able, industrious, and eloquent Cabinet Minister who had not specialised in those subjects? Lord Moulton happened to be both the specialist and the organiser; hence his particular fitness for the great authority he wielded throughout the chemical campaign.

Mobilising the explosives meant mobilising industries which have ordinarily nothing to do with explosives as such. Dyeing, making alcohol and soap and chemical manures and gas for lighting and warming, extracting coal-tars, and so on, are not war industries. But Lord Moulton's committee had to rope them all in more or less, and often to control them. The industries that mattered, directly or indirectly, had in fact to be conscribed. One after another they had to be called up—and at a period when the voluntary system as regards military service still lingered! The Explosives Supply Department in 1915 began to organise the production of ammonium nitrate in co-operation with the chemical manufacturers. New works were hurried on for new processes in order to utilise available materials and reduce our dangerous dependence on imports from abroad. The importance of ammonium nitrate increased as the war went on, and in 1917 a State factory was built and equipped to make it by a special process. Economy in materials grew more and more necessary as our tonnage diminished in 1917 and 1918. We had to examine closely into manufacturing methods in order to apply to the industries the most efficient methods. The experience won through the new State factories was most valuable for this purpose; besides, it aroused wholesome competition

among the outside industrialists. For instance, to obtain the maximum of glycerine, the newest and most efficient methods were stimulated in soap manufacture.

The more we look into the work done in these years, 1914–18, the clearer it grows that whilst concentrating on war needs we were preparing for peace progress. The fact is not less true of chemistry than of engineering. Catching up Germany in war meant catching her up in peace industry. She was far ahead of us in all sorts of enterprises in metal and in chemical industry; and a remarkable fact about those enterprises is that in several instances they were actually proposed or invented by not German but British brains. One of these has been already mentioned, the Haber process. There were others not less striking. An English chemist first proposed to utilise the waste product of coal tar. His idea was not taken up here. It was in Germany; and out of it came her great dye industry, on which the world before the war virtually depended.

CHAPTER VI

IN THE STEEL SHOPS

No survey of the munition movement can miss out the shipyard. The shipbuilding effort, the race of the merchant shipbuilding for life or death, to defeat by intensive production the submarine campaign, did not come, strictly, under "munitions of war." Yet, in some feature or other, munitions found their way into every yard; whilst the chief component of every considerable vessel, merchantman no less than ship of war, was the great raw material of all munitions—steel. Long before the war we had lost our old proud position as the greatest producer of steel in the industrial world. In 1913 the United States' output was more than fourfold, Germany's more than double of ours. Yet we stood third on the list, our steel industry was still a mighty thing. To realise the difficulties of a nation plunged in a huge conflict, without steel—without coal—from its own mines, one must look at Italy. Private firms, such as the Pirellis, did fine work for Italy in the war; but her national munition effort was cruelly stinted through want of steel. Neither ardent patriotism nor scientific ingenuity could make up for that.

In the hives of industry through the north of England and Scotland, as Tyneside and Clydeside,

the production of weapons for the armies and the production of weapons and vessels for the navies often were so associated that they appeared to form an inseparable whole. I was at Clydeside and its iron and steel neighbourhood, in 1917 and 1918 at different seasons in the year, and it appealed to me as the most wonderful creative base I saw either here or abroad during the struggle. It was impossible, as I have said, to understand the Front without some study of the Base made on the spot or through trustworthy information. Behind the field of Mars lay the forge of Vulcan glowing all over the industrial North, night and day, for more than four years. Except in its light one could never really understand how the fighting forces were eventually able to drive the enemy into armistice and surrender. This light, after everything has been said about labour and other difficulties, was intense and wonderful at Clydeside. I happened to see it there for the first time soon after returning from the huge Italian offensive against Austria in the Julian Alps and the Carso in August 1917. That fighting front offered a superb spectacle in natural environment and human drama. Yet passing down Clydeside a few weeks later, witnessing munition factories and shipyards striving to produce the goods, I found nothing tame or uninspiring in the home scene. The place struck me as one vast seething workshop. A day or two spent at Clydeside in 1917 and 1918 helped me more than any figures to realise how we were able at once to arm ourselves *cap à pied* and yet to ship masses of munitions to several of our Allies. It revealed clearly the mighty material resources of the nation, as well as the massed man-power at the Base, even after eight to nine millions

of men had been drawn into the British Empire's armies all over the world.

There is a strange attractive paradox about the scenery of Clydeside and the surrounding districts—the constant association of the hideous and of the beautiful. You may pass down the Clyde out of Glasgow and wonder for some time whether you were ever in more lowering, dismal environment. The blackest parts of the Black Country on the most blighted day have struck me at times as not worse than Clydeside in summer or autumn with a great shroud of fog above and around the city and its surrounding country: I am not sure they are quite as bad, leaving an impression so utterly gross and material on us—there is something so vast and amorphous in the hideousness of Clydeside in its dark moods. Yet it is very likely that, returning a few hours later up Clydeside into its metropolis of manufacture, you are struck by the noble charm of your environment. I have gone into a shipyard, steel shop, or other factory, when the whole countryside has appeared dipped in grime, squalor, misery, and come out, not long afterwards, to marvel at the loveliness or at the stately splendour of the scene; its faery spectacle of shipyard scaffoldings, and that ever magic scene of tiny figures scattered along great lengths and heights of rusty metal on which they are raining their multitudinous blows—the ship riveter and ship caulker at their heavy labour!

Oppressive though the Clydeside scene is in foul weather, in fog and rain and grime, and squalid and mean as the homes of great masses of workers appear in such conditions, in one way Clydeside notwithstanding was always heartening from August 1914 to

the close of the war—it was expressive of such an enormous energy. There is that in the presence and display of giant human energy, in the inspiring presence of a mighty making, which always alleviates the oppression we experience in otherwise dismal and ugly scenes. Clydeside can be repulsively ugly, there is no denying it, and Clydeside has large patches of slumland which look terrible and menacing in smoke and rain. But the expression of strength, of vital force, the sight and sound of creation, are over it all when the hammers and presses and lathes are going! That redeems the ugliest scenes. One experienced the same feeling in the factories over great stretches of the black country in Scotland and the North of England; but in few places so powerfully as in the glorious, terrible Clydeside district. No place can be wholly oppressive, no matter how repulsive to the eye, wherein the human drama is being continuously played on a vast, dominating scale. I floundered through the mud wilderness between Ypres and Passchendaele in autumn during the war, and seemed to reach the utmost limits of ugliness and repulsion: greasy, blood-stained duckboards, smashed military equipment and debris, innumerable shell-holes filled with mire and stagnant water, the marks of wrath and death in all directions, and not one natural object of green beauty from horizon to horizon. Yet utter oppression has even in that scene been in some sort kept off by the sense of a tremendous, forceful drama being enacted.

A like phenomenon lifted up the heart somewhat in those factory and ship-making scenes in the North and Midlands in 1917 and 1918.

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The Roman had a saying, *Laborare est Orare*, "Labour is Prayer"; and the French artist, J. F. Millet, symbolised this by his picture of French peasants standing with bowed heads in the evening field at the sound of the Angelus. Certainly the devotion and faith of a prayer could be seen any day during the war in the shipyard where labour was shaping the frames for a merchantman. One could see it on Tyne, Clyde, Tees, in any yard where new ships were building—ships that in 1917 and 1918 simply meant life to the nation. The whole scene of the framing was magnificent. It represented a triumph of the harnessed forces of fire, steam, electricity, and of huge machines. But it was a triumph, too, of sheer manual force and endurance. When all has been said in praise of the machine in war industry, the man at the Base, even as at the fighting Front, did stand out as a dominating, mastering factor in this work. Complex, ingenious machinery in many branches of factory and shipyard work bespeaks the triumph of mind over matter: and yet, when the red-hot frame is laid on its iron floor and is being curved and beaten into the right shape, we see, too, the triumph of muscle over matter.

The forge door is opened. The men hook hold of and drag out the bar steel section, say, 50 feet long. Directly it is out of the fire, they make fast the frame by iron "dogs" slipped into holes in the floor. They seize the edge with pincers, three men to each tool, and bend it back from the right angle. This is bevelling the frame; and, whilst it proceeds, other men are dealing the frame a blow here and there with the hammer: that is to keep it flat. The frame is bevelled in a few minutes, the edge is forced back

from the right angle. The dogs are moved, the frame adjusted a few feet away on the floor for the next process, which is "setting." The dogs secure the frame again, and a modest-looking little engine, the hydraulic ram, slips into action. This ram butts into one end of the frame still red-hot, and with perfect ease pushes it round into the exact measured curve required.

So now the frame is disposed of. It has been bevelled and set. The dogs are out, the frame drawn aside, the furnace door opens—out with the next! In an ordinary day each gang can bevel and set forty of these frames; working at high pressure during the war they produced as many as forty-eight.

Setting these ordinary frames is not the heaviest work of all in the shipyard: still it is the strong man's task. I saw women all over the country in 1917 and 1918, as well as at the working base in France, handling heavy hammers at times: but here, at the frames, woman's labour was unthinkable.

Yet frame-setting is not for young men alone. In any gang at work in those years I saw many men of over forty-five and of over the extreme military service age; and, with them, grey veterans of sixty and well over. A man of eighty was, in one shipyard of Clydeside, acting as head of a gang of frame setters, and doing his full day's work. Swinging the hammers, raining down blows on the red-hot iron, appeals to one as a task pre-eminently and solely for men in their twenties or thirties, men in the prime of their striking strength. Yet elderly men were wielding the hammers, too. Endurance is the first essential, but there is an art behind the giant stroke of the hammer, as there is behind the sweep of the

mower, or the drive of a golf ball off the tee. There must be a follow-through action with the hammer just as there must be with the scythe or with the golf club. Otherwise, force is misapplied, strength wasted, and not so good a result achieved. The hammer in the shipyard calls for strength, but not mere senseless brute strength. Physical skill and knowledge are essential: and that is where in the war years the veteran hand came in.

Passing from the covered shed where the frames were made into the open yard, one found the riveter and caulker at work on the sides and keel of a huge rusty skeleton. There were weeks of burning anxiety in 1917 and 1918 when riveters and their records were on everybody's lips—when it was almost a case of "The war will be won or lost by the riveter." Later, the riveter somewhat slipped out of notice. Yet really he remained all through a most vital figure in the ship-munition world. There was a substitute of sorts for his hammer, but there was none for the riveter himself; nor will there be one until some method of welding together ship plates instead of bolting and nutting them becomes an entirely practicable proposition. Such a change was only talked of vaguely during the war.

The riveter is the man who makes most of the noise, the workman's noise, in shipbuilding. Provided it greets the ear at not too close quarters, I know nothing in the grand opera of British labour sweeter than the ring of his hammer. When a great vessel by Clyde or Tyneside neared completion, and the work went smoothly forward, few things were more fascinating than to stand near the yard and listen to that harmony of steel striking on steel; the multitudinous

strokes coming so thick and fast they almost seemed to make one sound—a mighty unison, like a barrage on the battle front at zero.

Then, entering the yard, one enjoyed once more that familiar yet ever fresh and strange spectacle of tiny figures against the sides and on the decks of the rusty giant, whose completion seemed a task beyond mere human strength. The rôle of sheer hard labour, of muscle strength, is never more striking than when the riveter and caulker are in full swing against the bolted plates and keel of a great merchantman.

Here was a new ten-thousand-ton ship, a standard oil tanker, begun when the U-boat was still a grave peril. She was to be built in five months, and was near her launch. Riveters in gangs of three were at work on her sides and deck, caulkers were finishing her keel. Riveting is the hardest work of all in a shipyard; that is, taking the rolling keel and other difficult parts of the vessel with the simpler labour on the sides and deck where the men can stand and wield their hammer in uncramped attitudes. Unless we frankly face the strenuous nature of this work we shall never reach a true appreciation of the labour problem in the shipyards. To hammer home, say, six hundred rivets in a day of between nine and ten hours does mean an ungrudging outlay of physical strength. "Riveting does not put any strain on the intelligence, it is not brain work," an observer remarked to me. That is true; but eight or nine hours of it put almost the limit of endurable strain on the body and arms of even a strong man.

There was not much parade about the hardness of this toil during the war, among the men themselves,

so far as I noticed. It was all in the day's work. An old riveter on the wrong side of sixty broke off from his task in a Clydeside shipyard for a few moments to talk to me about his art—for there *is* something of an art even in riveting. He had been riveting ships all his working life — since he was an apprentice. Riveters work in threes, one man being the holder-up inside, the other two hammering in the red-hot rivets from outside, a right-handed and a left-handed man facing each other and delivering alternate blows. I advanced the theory that an ambidextrous man would be handiest for this work. But the old expert would have nothing of ambidexterity.

"After a time the muscle of a man gets set. He can't exchange right for left or left for right without a loss of time and power." No, a man must choose which arm he liked better and "abide by it."

He had hammered in a few millions of rivets in his time, so he reckoned : cold work when the wind blew hard on a man at the side plates in winter, and hot when the sun struck down on him in summer, but ships must be built all the same. The old riveter returned to his scaffolding, his hammer rang again on the steel. There is a great deal of sterling philosophy in some of these veterans of the shipyard.

We heard very little about the ship caulker during the war. This work is scarcely so heavy as the riveter's, but it is hard, especially when he is employed about the keel in stooping and awkward positions. The caulker has to see to it that the ship does not sink. He is furnished with a splitting tool and setting-in tool. His task, where the ship plates overlap, is to raise the steel surface ever so slightly with

his splitter, then hammer it home so that no water can enter at the point where the plates join. He has to make the ship water-tight, and there is plenty of close, painstaking work about that task. There can be careless caulking—which is found out with a vengeance when the time comes to test whether the ship is water-tight before she is launched. The riveter reckons by the number of his rivets; the caulker reckons by the number of his yards—forty yards, say, in a nine and three-quarter hours' day at threepence-three-farthings a yard. He is worth it all when the nation wants good merchantmen as fast as they can be turned out, water-tight.

All the acts and scenes in that mighty, resonant drama of shipbuilding during the submarine campaign were moving; such as the fixing of the great bulkheads, the building of deck above deck from the keel blocks upwards, even the carpenters' sawmills and woodwork, and the models in the draughtsmen's room. But the noblest spectacle one could look for in Clydeside in those days was the final one of the launch. The birth of a ten-thousand-ton merchantman, that was worth watching and recalling! There was nothing fashionable or festive about it, no champagne ceremony, no gay dresses, no social display whatever—but of what tremendous significance when you bore in mind what shipbuilding meant then! I recall, as if it were yesterday, the launch of such a vessel on the noblest tide in the North.

The final scene is all packed into some minutes of crowded, glorious life. Before she is released a few hundred workers in the yard line up behind and on either side of her, many of them tireless actors them-

selves in the drama now closing. They range themselves just clear of the scaffolding, within which lie, in two long lines, the heavy chains—land drags to take charge when she presently glides into the water, and to save her from running on the bank on the other side of the channel. The workers await the event without demonstration. One ignorant of the temperament of these northerners might suppose them indifferent, phlegmatic; whereas, actually, they are intent on the spectacle, keen and proud, many of them, over the fruits of their labour.

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A few isolated figures and on either side a small gang of men are still at work under the vessel. At the bows—she will take the tide stern first—one man is splashing in haste a touch or two of paint on to plates hidden hitherto by parts of the cradle just cleared. Two gangs quickly move upwards knocking away with a hand battering-ram the wedges that tighten and hold fast the bilge blocks. A few strokes, and each pile of blocks tumble down. The last bilge blocks are down, the corresponding keel blocks at her centre underneath have already disappeared. Next a man or two strike out the small iron "dogs" that here and there fasten the settled way to the sliding way which, heavily greased, lies on it and will travel with the vessel into the water.

Nothing remains to hold her back except the "daggers" on either side: in fact, she is held by a thread such as a little child might sever, and yet so perfect is this mechanism of the launch that she is held absolutely secure. But she knows the moment of her deliverance to the water is almost come! Though immobile to the eye, she is straining for the

water, as one can discover through a very simple test. Near the stern of the vessel a long nail has been driven into the settled way below, another into the sliding way above, and the two nails touched and crossed each other a few minutes ago. Look at them after the keel blocks and the lowest set of bilge blocks fall: they still touch. Look again after the last pile of blocks go, and the nails have separated by the best part of an inch. When the launch expert notes this he can smile and rub his hands in glee. All goes well. She is alive, almost imperceptibly she has stirred, and is now eager for the tide that awaits her below.

The dogs are out—immediately, at the signal of a whistle, the daggers on both sides follow in the same second, and then ten thousand tons glide to the water. It is a journey of under a minute in all from the removal of the dagger till the immersion of the entire ship's keel under water, and it is a thing to be watched through each instant. There are two impressions stamped indelibly on the mind of the observer—the quietness and the smoothness of it all. The Ancient Mariner's calm on his painted ship was not deeper than that of this great merchantman moving down the incline.

She has left the settled way like a shadow, and quiet as a shadow. The thing is wondrous. The beauty of it holds us for some fifty seconds as a spell. But then some one cries, "Keep clear of the chains!" and directly afterwards there breaks out the clang and angry rush of the iron links hot in pursuit of the escaped ship. They churn up the soil all about the spot where she lay for months an ugly rusty skeleton being hammered and screwed up into a live ship, now

at last with a will of her own that has to be restrained by iron chains.

The chains rush down to the waterside and stay there. They have done their duty and she floats free on the tide, safe from the mudbank opposite on which she might, but for their restraint, have plunged.

So the spell is broken, yet the magical scene is not quite over. One looks away from the ship swinging round with the full tide. In a few minutes (it can hardly be more than five) one regards her again, and notes this strange fact—she has actually started up the river! The tug is taking her to the engineer to have her machinery fitted. Among the people in war work who did their "bit" in that grand Admiralty push, getting things done without losing one minute, the little puffing tugs that waited upon the launch deserved a word of praise.

As for the crowd of hands who lined up for the launch, it melted away with the ship. Within five minutes it was already hard at work upon the next skeleton merchantman.

But the building of that merchantman was not really started in the Clydeside yard. To witness the preliminary stages one had to go inland, though not so many miles, and watch first the ore straight from the mine passing into the blast furnaces to come out into the flowing channels of pig-iron. The scene in and around these blast furnaces, and in the steel factories, always struck me as the *tour de force* of the munition-making world. The lurid splendour and the fierce menace of the thing appealed to some of us unceasingly. One watched it in the childlike spirit of constant wonderment. Of these three acts in iron and steel making, blasting furnace, Bessemer

steel process, and open-hearth process, the last struck me on the whole as the most magnificent, owing to the roll of smoke and to the various coloured flames rushing up into the sky; but there was not much between the three from the spectacular point of view. The North of England, notably of course the Sheffield district, furnished and furnishes the greatest wealth of steel and iron scenes; but one could see plenty of such scenery in one or two centres in the West of Scotland not far from the shipbuilding districts of Clydeside. For instance, there were the great works of David Colville at Glengarnock in North Ayrshire and at Motherwell in Lanarkshire. I spent a day there in 1917 and again in 1918 when shipbuilding, owing to the submarine peril, was munition-making of mighty moment. I believe it was in one of these factories, where iron ore was being rushed into steel for ship plates, for rails, and for all manner of urgent work, that the King after an inspection made a remark that will not be forgotten there, "I ought to have been an engineer!" The Glengarnock works exhibited a complete manufacturing unit for the making of all forms of steel sections from the native Scottish ores as well as the imported ores from the Continent and elsewhere. There were the blast furnaces, the chemical recovery plant for utilising by-products—the so-called "waste" which more and more has lately become one of the last things we can afford to waste; the basic Bessemer steel department; the Siemens open-hearth steel department; rolling-mills plant; basic slag manure plant; structural department; and last, the local ore mine from which is drawn the raw material out of which the pig-iron is made. The departments worked in close co-operation one with

another, so that the ores entering on one side of the works, after going through the blast furnaces, were presently converted into steel sections or steel structures, passed out on the other side: and as the steel was created, the valuable by-products, such as tar oils and basic slag manures, were secured intermediately. First, in seven great furnaces working chiefly on local clayband, the ores were converted into a highly phosphoric iron particularly suited for conversion into steel by the Bessemer process. Thence in the form of pig-iron they were carried in ladles either to the Bessemer or to the Siemens open-hearth department; the waste gases from the furnaces passing to the chemical recovery plant, where they were first cooled, then purified by water sprays, ultimately emerging through several processes as the fertiliser known as ammonium sulphate. This process and kindred ones were known, of course, and practised before the war, but they were developed after 1914 in various directions. Few things in modern industry are more remarkable than the knowledge, simply forced on us by necessity during the war, of the value of waste stuffs and rubbish. After all, the continuance of man on the earth, the life and growth of all living things, depend on used-up stuff and rubbish. We exist by the soil, and the soil exists by this endless repetition year by year of waste. The optical instruments of precision, hundreds of thousands of them manufactured in this country, would not have been made had not an expert discovered that a waste process analogous to these recovery ones would yield us potash in abundance. The value of rubbish and waste is one of the chief lessons, industrially, of the war. France was learning

the lesson at the Creusot works and elsewhere as we were learning it. There is a cry that the war has thrown us back industrially, perhaps ruined us. I do not believe it for a moment. There is a throw-back, but it is temporary: in a few years, if we keep our courage, we shall be more forward than we dreamt of in 1913 or 1914. Great Britain scarcely came out of the Napoleonic wars a century ago with a greater knowledge of science in industry than she possessed when she entered them; whereas she came out of the world war immensely fortified by fresh knowledge *and application*. The people who are obsessed by the figures of the National Debt are obsessed largely by counters. The true wealth of a great nation is not the temporary abundance or dearth of gold or silver reserves. It depends incomparably more on skill and science in production; and we have enormously added to our store of these during the last four or five years. I agree we are not yet using this newly acquired and proven knowledge to anything like its full capacity, but that is not because the mere money figures are against us or are very menacing. It is because we have not yet realised the absolute necessity of establishing an up-to-date working system between the two sides in industry. The old wage and hire system in industry—there is not the shadow of a doubt about this—has been discredited and largely overthrown in the course of the war and the munition movements from 1914 to the end of 1918; and we have yet to substitute a successor to it. When that is done the figures of the debt will speedily lose half their terrors.

Part of the iron from the blast furnaces at Glengarnock and elsewhere is turned into steel by the Bessemer

process, part by the open-hearth process. At Motherwell the latter alone is used. In the Bessemer process, which is so fascinating to watch, the conversion is done by the passage of air under pressure through the material: out of it as a waste product came the phosphoric basic slag manure which was invaluable during the war when supplies of foreign phosphates could not be shipped to us. These basic slags also came from the open-hearth process.

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To realise fully the mastery which man has obtained over matter, over the most obdurate adamantine forms of matter which can be imagined, one must enter one of these great steel shops—for instance, those at Motherwell—and watch the iron ingots and the scrap-iron being cooked and served up. The power of resistance which iron and steel can offer to man is then seen to be puny. They turn out, after all, to be exceedingly malleable substances. They are melted and cooled and remelted, and poured into tureens or ladles as securely as water into a goblet. They are rolled from shape to shape in their hardening state, and even when quite hard and cold are chopped and snipped as wood is by a sharp axe. You see something of this even in the shipyard, where there are guillotines to snip up angle bars of cold steel half an inch thick as if they were bits of wood; and where there are borers to drive rivet holes through much thicker plates than that. But in the shipyard it is the already treated and prepared product that is worked up; the angle bar, ship plate, bulkhead have been formed in the main. So we must turn to the steel works to witness the creation of the thing. The steel works—with the blast furnaces immedi-

ately before—were the birthplace and cradle of those bulkheads, frames, and plates which were riveted into position in the great ship-making movement in 1917 and 1918.

Here, for instance, on the floor of the steel works at Motherwell in September 1918 lies ready for the railway a boiler plate ten feet by eight, and an inch and three-quarters thick. Alongside is another, forty-six feet by eight, and an inch and a half thick—a plate evidently for a ship-of-war's side. Let us see how they were wrought up into their present, their *refined* form.

First of all, coal, coal, coal; for without that nothing worth mentioning in the shipyard, steel shop, munition factory—gold compared with coal being mere dross. This one Lanarkshire steel concern devours and digests—I am throwing back my story to the late summer of 1918—a thousand tons of coal in a day, not steam coal but the ordinary material used in the household grate, though minced fine for the purpose. The coal is brought into the steel works by rail off the main line hard by. It is poured out of the trucks into hoppers and quickly converted to gas, for the open-hearth system in these works is entirely worked by gas furnaces. The gas mounts into the furnace, when it unites with air that has mounted through a separate shaft alongside. The two join in the furnace and this causes ignition; but they must be kept strictly apart from each other until they enter the furnace, which is built of steel and lined with firebricks and has four or five doors opened for the feeding. The food is pig-iron which, as we have seen, has been already blasted in an earlier stage, and scrap-iron. The scrap consists of great heaps of old rusty waste, odds and ends of every sort, which

appear very much as if they had been raked off the battle-fields of Vimy or the Somme—forbidding, dreadful-looking accumulations, but the melting-furnace is not fastidious over its diet. To the pig- and scrap-iron is added a certain proportion of iron ore, the crude material straight from the mines, notably from the mines of Spain; it serves as a kind of leavening. Like the coal, all this material is fetched by rail into the Motherwell works: the furnace doors are opened and it is discharged by machinery on to the fire. Not many years ago the melting-furnace was hand-fed. There is still, necessarily, some hand-feeding—very heavy, hot work—but it is exceptional. Furnaces carrying sixty to a hundred tons must be fed by the crane.

For twelve hours the furnace consumes its iron load, burning at a stupendous, dazzling, white heat. The term fire quite fails to express the intensity of the thing when the molten bath of steel is gleaming and spluttering within. The heat is so aggressive that passing near an open door we flinch involuntarily. Nevertheless, men work in close touch with this fierce spirit during day and night shifts of twelve hours apiece, allowing three-quarters of an hour for breakfast and three-quarters for dinner. It is idle to study the problem and mind of labour unless we bear in thought such a fact as this. The men work in this heat without much grumbling. It is all in the day's labour.

What is the best way to face the heat of the furnace? I do not intend a tract against alcohol, but it is certain that *water* is one of the best ways. The sage's "Drink water and live with me to be a hundred" might be paraphrased by at least one lusty veteran

in this particular factory thus: "Drink water and work with me here for forty years." I passed a man of seventy-three years of age in one of the melting-shops: he, at any rate, was not there thanks to something stronger than water.

After twelve hours the furnace empties its contents through a tap-hole on to a shute, which carries it down into a mighty steel and bricked cauldron. From that it is distributed to ingot moulds. The ingots, later, are transferred to reheaters or vertical furnaces, and when red-hot passed up by crane and grappling irons to rolling rails. They are brought to the cogging mill, which crushes them down from short thick ingot into elongated form—flattening them down from perhaps twenty to six inches thick. A few yards farther along the rolling gear brings them to a guillotine which shears them up. Here surely is the guillotine of guillotines, for by a single action it severs steel sheets still some six inches thick! This miracle is done by hydraulic pressure—water employed to cut fire. We have at least one guillotine in the country to-day able to deal with sheets of steel fifty feet by twenty-four.

There follows a fresh stage of reheating the steel after the cogging mill. It is then rough-rolled down; passed on to another roller which smoothens it, at the same time reducing it to the thickness required, and put aside to cool. By and by the cold steel is lifted by crane on to labour-saving castors and adjusted by hand under the final guillotine to be cut to the right dimensions. This guillotine is fitted at one corner with what is playfully named a crocodile. The crocodile, each time the guillotine goes back for a fresh stroke, bites up the long shreds or ribbons of

discarded steel into bits of a convenient size—scrap for feeding another furnace. So, finally, our steel plate, born and cradled in flame, is ready for the shipyard.

The steel factory looks a place where, when there is labour ferment through the country, one might have trouble over industrial questions. Decidedly it appeals to one as a place where heat might be engendered, a striking place, verily, in more senses than one. But I heard little on that score in 1917 and 1918 in the Motherwell district or in Ayrshire where this great industry was being carried on to great effect. The English workers there were members of the Steel Smelters' Association, and also there was the Steel Ingot Makers' Association with its English and Scottish members. The Scottish workers were connected with Conciliation Boards particularly. I found there were two of these boards, one of which was about thirty years old and quite successful in its methods. As a result there had been very few stoppages in the steel works for a long time past, and nothing in the nature of a savage strike. Questions in dispute were dealt with by an Emergency Committee consisting of representatives from two neutral works, and should these fail to reach a decision an arbiter was appointed. Decisions once reached either by the committee or the arbiter had always been honourably carried out by both men and masters. The Steel Ingot Makers' Association had a similar arrangement, but in that case there were standing committees; whereas with the Scottish Conciliation Boards representatives were expressly appointed for each dispute when it occurred. The employers formed a Steel Wages Association, which met as a body to

deal with the unions: the relations between the two were usually good. I found there had been some lesser delays in starting after holidays owing to overtime claims, but these matters passed to the Government's Committee on Production and had ceased to be dangerous. The multiplicity of different unions in the steel industry, sometimes competing with each other, was a drawback: the same difficulty occurred during the war in various industries.

The methods of conciliation in the Scottish steel industry before and during the war, applied to our great national industries generally, would not be sufficient to solve the labour problem with which we are faced. It is idle, and even perilous, to deceive ourselves in this. But they show what skill and discernment can do. Whatever system we determine to apply in the future in order to bring the two sides into true partnership, we shall need the spirit and the practice of conciliation everywhere. But there is another thing essential to a solution of this problem. Men with character and brain must feel they have a real chance of rising from the lowest rung of the ladder to the top. I spent some time talking one day in the North to the chairman of a very large and powerful industrial concern.

Of this captain of industry a friend said to me:

"—— must be drawing a good ten thousand a year from these works to-day. He knows every detail in them, and is constantly on the spot and working hard."

I asked if he had been long connected with the works. "He started here as a lad earning a few shillings a week," was the reply.

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A little of our steel—a matter, even this, of hundreds of thousands of tons—went to the making of nets and ropes to protect our shipping and harbours at home and overseas from the attack of submarine, torpedo, coastal motor-boat. Messrs. Bullivant alone at their Shotley Net Making Works prepared for the Admiralty close on 7000 miles of wire rope, as well as 20,000 tons of chains, shackles, anchors, etc. Everybody during the war heard and whispered reports about the miraculous net spread across the Channel from England to France to intercept the enemy submarines. Some pictured an intact and impassable metal net laid from shore to shore: others were inclined to class it with the Russian troops who passed through the country in 1914 in railway carriages, the blinds of which were drawn down. There was such a net between Folkestone and Boulogne, though it was never entirely completed. For one thing, the work of maintenance was beyond the resources of the craft available. Besides, neutral and Allied traffic had not at the time grown acquainted with the route to be followed, and, the Dover Patrol not being strong enough to intercept every vessel approaching, the boom was repeatedly fouled and damaged during the dark. Its moral effect on the enemy, however, was unquestionable: he did not know where he might not run into it: the cessation of sinkings off Beachy Head, and in the Channel generally, when work on the boom was going on, was eloquent proof of this.

This particular defence against the submarine was known as the Dover Straits Type, and was of the design of the original boom which in 1915–16 extended from Boulogne to Cap Griz Nez. Peg-top mooring-

buoys were moored across the Straits of Dover at intervals of 494 feet, and each of these weighed about 8 tons. By means of baulks of Oregon pine and jackstays, steel nets carrying from 48 feet to 96 feet were fixed in position from buoy to buoy. Where it was necessary to increase the depth of the defence a net of 36 feet was added to the bottom of the 96-feet net, making 132 feet in all. Cast-iron sinkers, 370 lbs. apiece, were attached to the under-side of the nets, 28 to each section, owing to the strength of the tidal stream in the Channel.

The "net across the Channel" was one of the sensational defences of the war, but actually Bullivants were engaged incessantly, from August 1914 to the close of the struggle, in a great deal of other net-making work of immense importance. So far back as 1909 the Admiralty had appointed a Boom Defence Committee,[1] which devoted its enquiries at first to the problem of surface attack, but later turned to that of attack by underwater craft. Especially it concentrated on the need of providing some form of resilient boom for defence against attacks beneath the surface.

As a result, something was known about defence against submarines when the war started, and presently a number of different types of nets and booms were invented and tested. Bullivants—who were the original inventors of the old defence net against torpedoes—produced five or six defences

[1] This Committee was presided over by the Captain of H.M.S. *Vernon*, and among its members were Captain D. J. Munro—then Lieutenant, and later King's Harbour Master at Cromarty—and Captain C. T. Hardy. In October 1914 Captain—later Rear-Admiral—F. C. Learmonth was appointed Supervisor of Submarine Defences, and afterwards Director of Mixed Defences.

against submarines during the war. Besides the Dover Straits type, they made the Cromarty type, the Standard Harbour Defence, the Standard Paddle Ship Defence, and Indicator Nets of two kinds. The Cromarty Type—the first one produced during the war—consisted of nets made of two-inch or two-and-a-half-inch flexible steel wire rope. Each net was 900 feet long, and it had a mesh of 12 feet square. It was supported by baulks of Oregon pine and Scotch fir, and the ends of each 900-feet section were held by steam-rendering winches on board vessels moored head and stern in the line of the boom. The net of the Standard Harbour Defence had also a 12-feet-square mesh, and was supported by barrel buoys at intervals. The Standard Paddle Ship Defence was a most ingenious device. It consisted of 12-feet-mesh steel nets which were swiftly conveyed from place to place by the Isle of Man's old paddle ships and laid down wherever they were required. It often provided " whilst you wait " quite a good harbour of refuge for coveys of merchant ships in submarine-infested waters, and it could be quickly spread in the sea and removed as needed. The Indicator Net was used early in the war.

A submarine running into an indicator net released and carried away a pram buoy with which it was fitted. The buoy contained a calcium flare or Holmes light, and the track of this could be seen from afar. But when the size and power of submarines greatly increased, and when various forms of cutters and protecting planes were employed, and when the hydrophone was evolved as a defence, the indicator net went out of use.

Bullivants were also at work later in the war

making several types of booms to entangle and embarrass coastal motor-boats. For instance, there was the Table-cloth Net Defence, a series of light jack-stays maintained on the surface of the water, which would immobilise these light and swift attacking or "mosquito" craft by fouling propeller or guards.

The best defence against a submarine, a destroyer, or coastal motor-boat, is doubtless to attack it. But we should have fared ill, both on sea and land, if we had not put a great deal of energy and intelligence into the production of the passive forms of munitions, as well as into the active. After all, the steel helmet and the gas mask were passive forms of munitions of war; and until we had adopted and perfected both of them we were not scientifically armed for war. The output of Bullivants and the other firms who, under the guidance of Admiral Learmonth, concentrated on steel nets and on booms, was of signal value to the nation. It embarrassed, and worked on the nerves of the enemy at sea all through the war.

CHAPTER VII

THE TANKS

A VAST amount of chaff has been scattered on tanks. In the early stage of the tank's career, its "hush, hush" stage, we all agreed to be light-headed about it. There was fun in its droll name and a guffaw in its playful division into sexes, the female with her machine-guns, the male with his additional 6-pounders. A tank was likened to prehistoric beasts, which it did not at all resemble; and its gait was regarded as the roaring joke of the war. Tanks in motion incited merriment in a good many people who saw them, and in millions who had not seen them.

I confess to be one of those less imaginative observers who tried to perceive the ludicrous side of a tank, but failed. The motor omnibus, when first seen in the London streets, looked a ludicrous monster; it struck one as having a certain likeness to a rhinoceros in motion. But I was never able to see Mark I., our first tank type, in that light, or any other type projected for, or used in, the war. The tank, as first seen on the Somme, struck me as a dignified, tremendously impressive engine of war. It aroused in me the feelings which battle cruisers were wont to arouse long since at Portsmouth Dockyard and Spithead. Some people held that the

tank's leisurely movements made for merriment; but great battleships travelling at a considerable rate appear to move leisurely, as do large beasts and birds—size masking speed to the human eye; and yet they are not ludicrous. Nor is there anything irresistibly comic in the spectacle of a powerful machine moving over trenches, and, where necessary, crushing down considerable trees and portions of buildings.

There was, however, at the start one thing about tanks which aroused joy, hilarious joy, in one—the embarrassment they must have caused the enemy. The Germans did know something about war and its best weapons! We had to learn from them in various ways, we had to copy, and endeavour to improve on, their devices. They gave us grim lessons in machine-guns; in high-explosives; and, if not in marksmanship, at least in sniping. They taught us about gas for offence, and later, about reinforced concrete "pill-boxes" for defence.

But as to tanks, it was we who taught the Germans; and we taught them so thoroughly that they had to take the lesson, though they learnt it somewhat clumsily and late in the day. It was impossible to doubt that the Germans must have bridled with indignation when suddenly the tank, even in its early and less efficient form, walked over their terrible wired lines, looked into their extraordinary system of dug-outs, and could not be stayed, unless difficult ground or faults in its early mechanism overcame it, except by a direct hit from a field-gun. It must have offended the enemy's Staff, as it certainly scared a great many of the enemy's fighting men. These feelings lessened after a while, for the early

tanks did not cause the widespread havoc they were represented as doing. They were not always "walking up the main street of Flers with the British Army cheering behind them." But, by and by, tanks materially improved, as the method of employing them improved; and the fact that tanks not only could, but sometimes did, move over machine-gun emplacements and crews, and flatten these into the ground, must have exercised a considerable effect on the German fighting man.

The uses and effect of tanks have not been exaggerated by soldiers who know about tanks. Where exaggeration at home for some time ran riot was in another direction. It was popular to represent that the war could be won, and won quickly, not by the infantry, the hard-fighting and well-trained man on foot, but by a great multitude of tanks. Ingenious spirits fretted over the "hide-bound stupidity," the total lack of "imagination," in our generalship in the field! Why not win the war by concentrating on tanks, instead of throwing away lives in useless infantry actions? Why not build and assemble tanks in their thousands, and then proceed to crush the enemy system of defence and put the enemy himself to flight along the whole line?

This idea at one time was almost as popular as that other one for building aeroplanes in tens of thousands, and so ending the war in three or four weeks. But there was nothing much in it. There was not, really. And had we adopted such a Colney Hatch policy we should have been beaten long before November 1918 and driven out of France.

Apart, however, from armchair strategy, the tank truly was one of the signal mechanical successes in the

war. It hastened the end; it spared us a great number of lives; and, as finally constructed and used, it showed that in military science and study Great Britain still remained one of the foremost nations.

The last point is especially worth touching on—for the tank shall here be described as a British invention. We led, indisputably, in tanks, from the outset. We worked out the design of the tank. We designed it. We applied it ahead of any nation, hostile or friendly.

There is no Chauvinism in these statements; but they are the simple truth. To be sure, other sources of inspiration than British, and other places of origin than Lincoln, have been suggested in regard to tanks. One idea has been that the tank, or at least, the caterpillar, crawled across the Atlantic before we had ever thought of it in this benighted island. The South Pole too has been talked of as the place where the embryo tank made its début even before the war. Personally, I do not take such suggestions seriously. Once we begin to indulge in them we may find ourselves back at the siege of Troy, and trace the tank to the wooden horse. The plain man will continue to believe that the tank did originate in this country, was first built at Lincoln in 1916, and made its début with the Fourth Army at the Battle of the Somme in that year—all-British in fact.

Who *invented* the tank? So many claims have been made in this matter that the public is naturally a little confused. In fact General Byng is one of the few people particularly associated with tanks (Battle of Cambrai, 1917) who has flatly asserted he did not invent a tank. Actually, there was no one definite inventor of the tank—it being evolved really

from existing means of traction, particularly caterpillar. The tank, like Topsy, "growed." Mark I. tank, mother tank, our primordial type, was made at the works of William Foster & Co., Lincoln. It was designed by Major Wilson and Sir William Tritton, managing director of Foster's. Mark I. was fitted by the Daimler Company at Coventry with a 6-cylinder 105-h.p. engine. The strain on the driving mechanism was very severe, and there were no kindly springs in the tank to assuage the tremendous shock when the all-steel and rigid monster fell over a wall or other impediment and crashed on to the ground, the other side.

The Navy, as well as the Army, had a hand in the design of tanks. In fact the Navy, oddly enough, was in the field before the Army, with Mr. Eustace Tennyson d'Eyncourt, the Director of Naval Construction, presiding over the Land Ships Committee, and Mr. Winston Churchill, First Lord of the Admiralty, pressing, with a foresight unusual among statesmen,[1] for some kind of armoured machine able to convey men across No Man's Land, break through the barbed-wire defences, and machine-gun the enemy in the trenches. Major Wilson and General Swinton had a large share in planning and pushing the tank. Major Hetherington's work must not be overlooked; whilst caterpillar traction, in preference to wheels, large or small, was urged by quite a number of enthusiasts. Lieutenant Stern, though not a designer or constructor, was a great energiser. They all helped to create "Mother Tank," though they may no more

[1] It is really idle to dispute Mr. Churchill's prevision in regard not only to aeroplanes but also tanks. His letter to Mr. Asquith on the tank idea in 1915 shows prevision.

have invented her than Harvey "invented the circulation of the blood and discovered Harvey's Sauce," as the little girl put it. And they had to overcome much stolid stupidity among old-fashioned military officials at home.

Later, came Mark II. and Mark III., which were Mark I. without the wheels behind; Mark IV., a slightly improved pattern of Mark I., which fought with the later types towards the close of the war, for instance at the Battle of Amiens in August 1918; Mark V., an improvement on Mark IV., the main difference between these types being that one man could drive Mark V., whereas Mark IV. needed four drivers; Mark V. Star, which was Mark V. except in length, the former being 32 feet,[1] the latter 26 feet; Medium Mark A, or the Whippet, weight, 14 tons; crew 6 men, maximum speed 8 miles an hour, whereas Mark V.'s speed was about 5 miles an hour. Improvement in design was immensely important; we should have been "ditched" without it.

Of these types, all tested by battle, the best all-round seems to have been Mark V., the machine which so impressed the French during their counter-stroke in July 1918. It had better climbing powers than the Whippet. It could span bigger trenches.

Mark I. and all the later heavy types were divided into males and females; the first being equipped with two 6-pounder guns[2] and four Lewis guns, the second with six Lewis guns. In 1918 the Lewis gun was exchanged for the Hotchkiss. As to the armour of

[1] Mark V. Star accommodated twenty men more than Mark V.

[2] These were all made by Armstrong Whitworth. This firm produced 3896 6-pounder guns and mountings for the male tanks.

tanks, Mark V. and the later ones were virtually proof against all types of bullets, which Mark I. was not. Throughout, the enemy's anti-tank measures were defective. The best defence against the tank lay in his mobile field artillery gun. Towards the end, the Germans realised the importance of defence measures, but it was too late to make good their earlier neglect. The German anti-tank mine was not terrible, and the anti-tank rifle, despite its armour-piercing bullet, did little damage. Near the close of the war, the Germans were, however, at length getting on with the manufacture of an anti-tank machine-gun—the " Tuf "—the bullet of which would pierce steel 30 millimetres thick. The Germans hoped to have by the spring of 1919 thousands of these guns in the field ; the first were to be delivered in December 1918. Their manufacture was not discontinued when the Armistice came.

As to the few tanks the Germans themselves built when they recognised the value of the weapon, these were quite inferior to the best of ours. The German machine was too heavy, and it could only move over flat ground, though there its pace was good enough. Moreover, it could not, like ours, cross formidable trenches.[1] One saw British tanks in their " parks " and in the battlefield, move over all manner of impediments in an amazing way, but they were liable to fail when the ground was very bad. Somme and Flanders mud was often too much for them. The

[1] Ours, of course, were sometimes in difficulties among the trenches. At the Battle of Cambrai I noticed them conveying a huge faggot or fascine which was to be laid down where necessary, for a bridge. Another engaging spectacle at this battle was the mass of ripped-up barbed and " concertina " wire which many tanks dragged behind them after passing through the Hindenburg lines.

ideal ground was found for tanks, for the first time, at the Battle of Cambrai, which on November 20, 1917, might be described as a good galloping country covered with the rough grass and flora of a typical piece of English chalk down country.

To get a fair notion of what tanks did for British arms in France during the two years and two months they were in action there, it is well to examine into some of their chief, and also their subsidiary, operations. The Mark I. tanks fitted with wheels at the back first went into battle on September 15, 1916. "In this attack we used a new type of heavy armoured car which has been of great assistance" (Sir Douglas Haig's despatch). The secret of their construction had been well guarded from enemies and from friends; though necessarily many mechanics and drivers had to move about various works carrying that secret with them. I happened to be at Amiens at the time, and dining at the Hôtel du Rhin on September 17, with some British and Russian officers, was able to describe to them—very roughly!—the appearance of the new machine, as I had just seen one which had broken down on its way back from the battlefield not far from Mametz. I found them interested and curious, but knowing hardly more about the new weapon than was known by the public at home. They still breathed, like Mr. Nadgett in *Martin Chuzzlewit*, "an air of mystery"; and there was a disposition to speak of the novelty in a fearful whisper. Its name or nickname was hardly even whispered. The veil was only partly lifted when, a few days later, the world heard a story of how a tank went up the main street at Flers with our infantry cheering behind it.

On September 15,[1] 48 tanks were employed for engagements at Delville Wood, Martinpuich, along the Albert–Bapaume road, and particularly at Martinpuich sugar factory. Seventeen were put into the Delville Wood attack, but only seven got fairly into action. They were not really successful in an attempt to aid the infantry, for some lost their bearings, whilst others were knocked out by enemy guns. Tanks fared better in the Martinpuich fighting, coming well into action and bringing valuable aid to the troops; whilst others, in a larger group in the same sector, exercised a useful moral effect on sundry enemy garrisons. Several tanks, too, operating with the Canadian Corps by the sugar factory reached their objectives; they could not make use of the 6-pounder guns with which the males were armed, but found some "nice" targets for their machine-guns.

On the whole, the fighting exploits of tanks on this, their earliest essay, were not equal to the sensation they caused among friends and foes. Their success was so so. They promised possibilities. They were a menace; and must have set on the German High Command thinking. They set us on shouting at home, which was natural. Perhaps the French may have been inclined to lament that we did not wait till their Army had its tanks too, and could strike with them simultaneously on the Somme with us, and that was also natural enough. Yet, had we waited for our Allies, the secret would probably

[1] The notes that follow in regard to tanks in action are military, rather than munitionary, and may seem somewhat out of place here. But it is well to give them, for they are official and state solemn facts about tanks instead of fantasies. They may help to disabuse the highly imaginative of the notion that tanks can fly, or swim and submerge like a submarine as yet, or that they can go into the dug-outs.

have leaked out, and a useful surprise and sensation been spoilt. We were right to try the tanks as soon as we could; there was not any time to lose, if we were to do anything with the new arm of war during the summer fighting.

Small numbers of tanks, from three to eight, took part in Somme fighting again on September 26, Mouquet Farm, Thiepval; also in a minor operation on the previous day, when one of them contrived to clear a trench holding up our infantry and to help in the capture of between three and four hundred men and officers. On October 17—St. Pierre Divion—a tank crossed the German line, and, operating with the Thirty-ninth Division, enfiladed the trench system for about twenty minutes. On November 14, two or three tanks operated at Beaumont Hamel with the Sixty-third Division. They were ditched on their objective, but fired twenty rounds of their 6-pounder guns into dug-outs and rounded up 400 prisoners.

That closed the operations of tanks during the Battle of the Somme. So far as I know, they were not used during the German retreat from the Somme in 1917. Clearly the tank was still in quite an experimental stage.

In the Battle of Arras, April 1917, tanks were brought out in about the same strength as during the Battle of the Somme. They fought on April 9 at Thelus, Laurent-Blangy, Le Point du Jour, Fampoux, Altries. At Thelus they failed. The ground was very bad, and they were all ditched between the German front line and their objective. Elsewhere one or two reached their objectives and were reasonably helpful to the attacking troops. At Tilloy, The Harp, Neuville Vitasse, etc., 15 out of the 20 tanks

told off for the operations started at zero. They had varying success. Four were ditched, or destroyed by enemy guns, during the fighting at The Harp; others were ditched in No Man's Land before reaching the German front line; but several did execution in the struggle at Railway Triangle, though later they were put out of action. The state of the ground was all against them.

At Neuville Vitasse they succeeded—even brilliantly; they seized the village and scared a large number of Germans into surrender.

On April 11, at Riencourt and Hendecourt on favourable ground, 11 tanks started, and—probably for the first time—replaced the usual artillery barrage. They played a signal part in capturing Riencourt and Hendecourt, but plans somehow miscarried and both villages were retaken by the enemy. On the same day, at Monchy le Preux, tanks decidedly aided the infantry to capture the village and La Bergère cross roads; and, zero being postponed at the last minute, as in the previous exploit, they started off without the preliminary barrage and partly cleared Monchy before the infantry came up—a distinct success, and a foretaste of their great doings later in the year at the Battle of Cambrai. The next important operation was on April 23, when 20 tanks were told off to take part in the fighting at Gavrelle, Roeux Chemical Works, and Mount Pleasant Wood. They suffered severe casualties through bullets and field-gun fire, but brought help to the infantry at all three places. On May 3, 12 tanks set out to help the attack at Bullecourt and Croisilles. They played their part well, but the attack itself, through other causes, failed.

So much for the Battles of the Somme and Arras. Next, Messines on June 7, 1917. Production was growing steadily, and faith in the weapon, in spite of sundry disappointments, had not vanished; in fact, in this exactly planned battle, we put in 72 tanks. Forty were launched at zero for the first attack, and more than half reached the line where tank co-operation was to start; they gave valuable aid in the reduction of Wytschaete. Nineteen tanks on the same day got into action with the later attack on the Oosttaverne line, where they were very effective. They patrolled in front of final objectives, and silenced German snipers whilst infantry consolidated behind them. Messines was a good day with the tanks.

On the last day of July, and intermittently through August, September, and October, they put in much work in Flanders. They were employed, in much larger numbers than at Messines, when we attacked on July 31, 1917, at St. Julien, Westhoek, Zonnebeke, the Pommern Redoubt, and elsewhere. But the ground was terrible at all these places, and the tank operations on the whole were not encouraging. In the Zonnebeke sectors the enemy developed a more effective anti tank defence than hitherto. His anti-tank and field-pieces did much execution. In August and September the tanks struggled against the mud and smashed roads of Flanders. In some actions they failed—for instance, Angle Redoubt and Inverness Copse on September 20; in others they obtained moderate successes. Perhaps their chief success was on October 4—Poelcappelle—when they secured Gloster Farm, and brought up ammunition for the infantry.

So far then, the tank in a year's trial had not quite justified the high claims made for it in September 1916. It had alternated continuously between success—moderate rather than marked—and failure, in the Battles of the Somme, Arras, and Flanders; and the experiences in the last of these great series were discouraging. But the caterpillar took a great bound forward on the first day of the Battle of Cambrai, when we suddenly struck into and clean through miles of the Hindenburg line at about its strongest point. The tanks here took the field in large numbers: 324 of them were employed on November 20, 1917, and their operations with one exception were a grand sucess. They were told off to attack, at Flesquières, Havrincourt, Ribécourt, Marcoing, Mesnières, and La Vacquerie, and their one very serious set-back was at Flesquières. On its ridge 16 tanks were knocked out in succession by a German field-gun in the open. I shall not forget seeing them there next morning when I managed to get past Trescault and into Ribécourt which was being cleared of the last of the German snipers. At the distance of a few hundred yards, they looked exactly as if, far from being casualties, they were preparing to start after the enemy, who had just retired from the village of Flesquières. The set-back—which most seriously interfered with the British advance and the fate of the battle—was largely due to the courage and iron will of one German officer who served his gun, when all his men were wounded or dead, till he was shot. Havrincourt and Graincourt were taken by the tanks, with the infantry hot behind them, in record time. At Ribécourt, Marcoing, La Vacquerie, equally good work was done, and throughout this

wonderful day *the co-operation between tanks and infantry*—without which there can be no real success—was excellent. November 22, too, was good for tanks. They were at Cantaing and Noyelles, using their 6-pounders to good effect. They entered Crèvecœur, but unfortunately owing to counter orders were not here followed by the infantry. They reached Bourlon Wood and their objectives round about it next day in strength—35, I think, out of 39 employed—and though attacked to the right of the wood by anti-tank guns, which caused a good many casualties, greatly helped the infantry. By this time, however, the enemy were wide awake to the danger of the brilliant attack near Cambrai. Reinforcements were rushed up, and anti-tank defensive measures taken. The surprise and its stunning effect were past. The ground, so firm and favourable at the outset, was churning up. From November 23 to the close of the month the tanks, though active, did little good. They entered Bourlon village and Fontaine, but could hold neither. The infantry were sometimes too sparse, sometimes too exhausted by the heavy fighting of the first few days. Besides, many tanks were knocked out by the enemy.

On the 30th came the great German counter-attack at Cambrai and their break-through to Gouzeaucourt, and on this and the next day the tanks—some 26 of them—which had been preparing for entrainment, were sent in, rather late, to help the infantry. Their success, on the whole, was moderate. They destroyed or silenced a number of machine-gun emplacements; in Gauche Wood they ran over and simply flattened into the earth machine-

guns and crews which did not take to flight. Also crews of knocked-out tanks gave the infantry some valuable service with their machine-guns, as in the fighting in the Gonnelieu sector.

The opening day of Cambrai is to be remembered as the classic day of the tanks. A great deal was claimed for them in the first flush of success, but it is doubtful whether too much was claimed. In spite of their numbers, and the great difficulty of assembling and preparing them unobserved by the enemy, they effected a complete, an amazing surprise. They helped every Division except the 36th, the Ulsters, on the extreme left of the attack, for whom they were not provided by the battle scheme. A true understanding existed between them and the infantry. Except at Flesquières, they carried all before them in the attack. They stamped down and cleared away great quantities of barbed wire in the Hindenburg and Hindenburg support lines. Finally they served instead of the preliminary barrage which forbids a sudden surprise.

After the exultation at home over the first days of Cambrai there was a reaction—a natural reaction but ignorant. But among those who had made an intelligent study of war, there could be no reaction against tanks after Cambrai, though in the later phases of that heroic battle they were less successful than on November 20. Henceforth the tank had come to stay; that was clear. It was sure to be developed in construction, and to be built in larger numbers against the final stage of the struggle.

The last stage was our defensive, then our offensive, in 1918—March 21 to November. In that tremendous series of assaults tanks fought, I believe, on

fifty-five days, in light and dark. In the official records I have noticed that not less than forty-seven distinct operations by tanks during the drive of our army by the Germans and our drive of the Germans were described as successful; sixteen as moderately successful; only six as unsuccessful.

They started with local counter-attacks on the opening day of the great German offensive. At Doignies the enemy climbed on the top of the tanks trying to get in! Next day 71 tanks were engaged in defence and local counter-attacks about Epéhy, Vaux-Vraucourt, etc. They suffered some heavy casualties, but they killed and wounded a great many Germans. On March 23 several tanks which had broken down near Moislains were used as strong posts from which to harass the enemy. On March 27 on both sides of Rossignol Wood they put down a barrage from Lewis guns. Heavy tanks and Whippets were both engaging in these fights, and on April 12, north of Villers-Bretonneux, the former for the first time met and fought enemy tanks, putting one out of action.[1]

On July 4, 1918, Mark V. made its first appearance. Sixty-two tanks were put in near Hamel to co-operate with the Australians. They entirely succeeded, with small casualties. The success of Mark V. was repeated

[1] Major Clough Williams-Ellis in his excellent book, *The Story of the Victorious Tanks* (published by "Country Life"), writes that, in all, only fifteen German tanks were manufactured, the remainder of the curiously ineffective and casual enemy tank corps being made up by twenty-five captured and mended British machines. Co-operation between the German tanks and infantry was not encouraged, indeed the contrary. Moreover, the crews were not welded together into a good working whole. The attitude of the German High Command, till too late in the war, seems to have been one of obstinacy; so that even when they were building or planning to build these machines they were proclaiming to their men the ineffectiveness of the weapon.

on July 25 at Moreuil, and powerfully impressed the French infantry and staff; though in this case the time-table was somewhat slow for tanks, and after the first objective had been reached the smoke did not give enough protection owing to wind and rain.[1]

The Battle of Amiens, August 8, saw no less than 430 tanks, heavies and Whippets, in the field. Almost every objective was gained and the enemy was completely surprised. On August 9 and 10, 240 tanks were put in to co-operate with Australians, Canadians, and cavalry. There was a check in the tide of success, and attacking without smoke in daylight the tanks suffered severely; but between August 11 and August 24 Mark IV., Mark V., and Whippets scored in almost every engagement. In one Whippet the solitary unwounded man heroically drove into action himself.

From that time onwards "all objectives reached" grows familiar, "unsuccessful" days rare and rarer, though stout opposition was encountered, as in the crossing of the Drocourt–Quéant line, September 2. An interesting incident occurred in the fighting on September 27, when about Bourlon, Gouzeaucourt, and Trescault some of the identical tanks and crews took part which were engaged there during the Battle of Cambrai, 1917. On October 6, near Forenville, the enemy counter-attacked with four captured British tanks, but was quickly repulsed and put to flight. There was no big action after this one in which 82 of our machines were engaged; and on

[1] The French had heavy tanks, but their special tank was much smaller than our Whippet. It was named the "Baby Renault"—after the Renault munition factory near Paris where it originated. It was speedy and light, armed either with a machine-gun or a quick-firing one-pounder. The French started building their tanks in 1916, and towards the end of the war they were produced in large numbers, sometimes over thirty a day.

November 7 the tank operations closed in some lesser fights about Avesnes and Cartignies, the Armistice ending the struggle four days later.

This brief record of the work of tanks between September 15, 1916 and November 7, 1918 leaves out, necessarily, many set-backs, disappointments, and failures to co-operate scientifically between machine and fighting man on foot. But it demonstrates that the tank became a great arm of warfare on the British side. Long before the Armistice it had passed out of the purgatory of doubt and experiment. It had become a comrade and a heartener of the fighting infantry, and a disheartener of the attacking or defending enemy troops. It kept down our casualties, and quickened the capture of a large number of villages and strong points.

At the close of the struggle the tank had become, incontestably, an up-to-date and invaluable weapon of the most modern and scientific warfare.

At the last phases the Germans were preparing an anti-tank machine gun of great defensive power, but at the same period we were preparing a tank of greater size and strength than any type we had yet put in the field. Whether Mark VIII. would have proved as great a success as Mark V. is a question. Some experts thought it was not such a good type; but we had arranged to build it in large numbers, and the American Army was to share in the Mark VIII. programme. It was to be the Allied tank. Mark VIII. never went into action, but I was so fortunate as to see it being built in one of the factories near Manchester, and also at the same time to see its engines being produced. To have a hand in making tanks appealed to the imagination of many workers. Men

in the North were often heard to express their satisfaction in turning from some kind of stereotyped munition labour to the building of the hull of a tank. They felt then that they really were doing war work; and there was not the deadening monotony about this production that there was about so many forms of munitions. The building up of Mark VIII. was an inspiring spectacle in the autumn of 1918.

When some of the first tanks in 1916 were knocked out of action, it struck one that here was something like an irreparable loss. How in a short time could the exertions in our armouries at home make good such heavy losses in war material cast on this colossal scale? People, no doubt, who are familiar with steel rolling-mills and heating and blasting furnaces in the North would not view it in that light. A tank to them would appear quite an inconsiderable outlay in material and exertion. But outside the steel and iron district a different impression often prevails. A tank to many of us suggested at the start such a slow, immense labour in the making! As a fact, the labour in making the hull of a tank was heavy—but it was not slow. Had the Mark VIII. programme been proceeded with, we might have been producing in 1919 300 a month of this type, which weighed thirty tons.

The plates for the hull of Mark VIII. were reaching the factory when I visited it in three forms—armour plates, bomb-proof plates, and mild steel. They were drilled and cut to the required dimensions, heated in furnaces, dipped red-hot into baths of whale oil for tempering, and a few minutes later drawn out to be hammered flat by hand work—heavy labour fit only for strong men. Women were working in this tank hull factory, but here was a man's exclusive department.

After these processes each armour plate had to pass through a thorough and most searching test. It was taken into a range in the factory and shot at with a German rifle at 25 and 50 yards. The plates of the hull, the coverplates for the turret, and the whole of the tank indeed, were assembled as the parts of the aeroplane, etc., were assembled. From the assembly-room they were despatched to the seat of war, standardisation being the method with tanks as with so many other forms of munitions. Standardisation of material and exact subdivision of labour—without these two methods we could not have won through. They meant an immense economy in effort and time and a vastly increased output. We want to get the utmost we can out of a machine, whether it be war or peace produce, at the minimum expenditure of human exertion, of money, and of time ; the way to this is by standardisation of parts and by repetition tasks.

A heavy tank, Mark VIII. notably, with its hull built up complete—for, like a new vessel in the shipyard, it was actually built up on wooden blocks—appeared a simple enough structure. It did not appeal to the eye as a very elaborate thing, with a wealth of fine or curious detail. Yet this appearance was somewhat deceptive, for here in reality was an object composed of 730 different parts, and for the making of these parts there were needed not less than 620 templets. The templet is the steel pattern by means of which each separate piece of a tank is produced with accuracy ; and accuracy has to be ensured in building tanks, though the measurements may seem those of extreme tolerance when compared with, say, master gauges. The little templet department

of the tank factory struck one as a model in its nice order and arrangement—hinges, bolts, every tank detail having its proper niche. A place for every templet and every templet in its place.

From the factory where tank hulls for Mark VIII. as well as for Whippets were being wrought, one passed to another factory where the engines for the super-tank were preparing. This engine was one of 300 horse-power capable of 1200 revolutions in a minute. The first one I saw complete and being tested was whirring its 1600 revolutions the minute. The seeming simplicity in the design of Mark VIII. was absent from its engine, which was made up of hundreds of pieces, some of which had to go through twenty distinct operations in the various departments of the factory before they could pass their final test. Intelligence and real head work are needed among the workers as well as hard manual labour in the making of the tank engine.

"I have never yet been in this room and found a man idling—and I have been in it at all hours, day and night," a works manager told me.

The room was one in which patterns for certain complicated parts of a tank engine were prepared. Owing to technical difficulties these patterns had to be made in wood, nicely cut by hand. They could not at this stage be cast in the foundry. That is work which demands close application and no small judgment. It demands patience, too, to secure exact finish. Yet, as it happened, the work was not nearly so well paid as a great deal of work of a far less skilled kind. The whole question of remuneration was no doubt in a chaotic state through the whirlwind of war. Standard wages, bonuses, individual and

collective, premium bonuses, piece-work generally, were a tangle it was impossible to smooth out. There is still absurd exaggeration as to the fabulous profits which munition workers, especially the unskilled or semi-skilled, were supposed to be making. Eccentricities in wage-earning are quoted as if they formed the rule, not the exception. Inane nonsense was talked about munition-workers dressed in costly furs, decked with real pearl necklaces, and playing on Broadwood grands. That was bad caricature.

Yet it is true that highly skilled work was often much less profitable than semi-skilled or unskilled. Here in the tank engine pattern room was an example —men earning not above £3 : 10s. a week. The room was in a district where unrest and strikes were rife. But there was no trouble or mischief afoot in that pattern room. Why? One opinion was that intelligence, education distinctly above the worker's average, were there. The men, though undemonstrative, understood the urgency of the call. They took a serious view of their responsibilities, though alive to the fact that their reward compared ill with the reward of many less intelligent workers around them.

In some war factories, to meet with a higher plane of intelligence was to find a higher plane of responsibility. True, there were loose, mischievous spirits in highly skilled departments of workshops, but they were mostly confined to a bad leaven of young men who were conceited through a smattering of knowledge. Their education was a thin veneer, and left in this state it was worse than no education.

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The total number of tanks, excluding Mark VIII., built by us during the war was 2817.

CHAPTER VIII

THE AEROPLANES

"I hardly ever encountered an Englishman who refused battle."—BARON VON RICHTHOFEN.

THE war so dwarfed all our peace-time pageants and manœuvres, military and naval, they seem to date back to the days when we played with tin soldiers or sailed a mimic ship on the Round Pond. Yet there was a display at Spithead in 1912 that I recall distinctly because an entrancing feature of it was an essay in flight. A few enthusiasts had been experimenting at, I think, Portland in the new naval arm, and July 9, 1912 was to be a day of aeroplane and seaplane exercise with the fleet. I travelled down to Gosport and went on board H.M.S. *London* on July 8 hoping to witness a wonderful naval spectacle next day—an aeroplane take flight from the ship which had been fitted for the purpose. That performance never took place. I had hardly been on board ten minutes when the boat bearing the aeroplane to us was swept by the tide too close to the side of the *London*, and the machine was smashed. Repair in time for next day's exhibition was impossible, so the wreck was taken back disconsolately to shore at dusk, and we had to content ourselves on the 9th by watching the flights of a few other aeroplanes and seaplanes

which started from the land. Even that struck one as a marvel. The more ardent watchers were sure that the age of flight as an accessory of sea and land warfare had begun. They discussed the possibilities of aerial fleets in the future.

The enthusiasm waned after that faery day at Spithead. The wise shook their heads at the notion of spending money and energy on a toy. Yet the idea was not abandoned. It found a few keen friends, and two years later Great Britain had at least the nucleus of an air force. The efficiency of the machine itself, moreover, had improved not long before the war. By August 1914 we had the Royal Flying Corps, 179 machines, and the Royal Navy Air Service, 93—a total of 272, with a personnel of about 1850 officers and other ranks.

Compared with what was to follow, when after about a year of war the manufacture of aeroplanes started in earnest, those figures seem contemptible. In ten months of 1917 we produced between 13,000 and 14,000 machines, whilst between January and October 1918 our output of machines reached the total 26,685. Monoplanes, biplanes, triplanes—we built and experimented in all three on a great scale. The first type was usually voted to be best for the quite small aeroplane: the second for general sizes: the third for very large ones. We produced pushers and tractors in bulk. We turned out a great variety of sizes. For instance, the Sopwith-Camel, a small fighter, had a total weight of 1454 lbs. when fully loaded; whilst that of the Handley-Page O/400 was 13,200 lbs., which included 1800 lbs. weight of bombs.

At the time of the Armistice no one who visited the national factories devoted to flight could suppose

we were past our zenith of production. We were then able to produce about 3500 machines—complete—a month.[1] Of all munition factories at that time I do not think that any were quite so impressive, so nobly planned, as those built and equipped for flight.

Though Great Britain at the close of 1918 had the finest air service in the world, and was the greatest producer of machines and engines, she was backward before August 1914. It must not be thought she alone of the nations was backward. Germany had still a vast deal to learn through the war. Ahead of all the Powers in this arm, as in most others, Germany yet had not dreamt of the output of aeroplanes her manufacturers would be called on to make between 1916 and 1918. The French had shown imagination and aptitude for flight before the war, but France had apparently not more machines than had we in August 1914. They began, like us, with a hundred or two, and at the end of the war they had eleven thousand or so, in active service or ready for service, and in training camps.

We were unprepared for a huge land campaign, and in some branches shamelessly, stupidly unprepared owing largely to national temperament. This is especially true of those war industries [2] in which we had placed ourselves at the mercy of German monopolists. But no purpose save that of the railer is served by representing that, whilst we were behindhand in everything, Germany, France, or some other nation foresaw and provided against everything.

[1] The average number of machines supplied monthly to our Army and Navy together during the first year of war was 50.

[2] See Chapter IX. "Key Munition Industries; and the Work of Science."

They did not. And only the tiresome fellow who proclaims, "I told you so!" and his parrot can suppose it. Germany had more machines than Great Britain and France together, and her engines were more powerful; but it ended at that. Most of to-day's marvels in flight were war results unforeseen by Germany, by France, or by ourselves in 1913 and 1914. The climbing feats in defiance of the wind,[1] the aerial duels, the low, skimming flights, often against the wind, they were born of the wholly unforeseen progress of the war. As to the third of these achievements, it has some times appealed to the watcher as the most wonderful if not the showiest, and certainly as one of the most daring.

Motoring from Albert to Bapaume soon after break of day in November 1917 there repeatedly passed one on the road British aeroplanes hasting to the battlefield. They were skimming so low over the wastes of the old Somme battlefields as to remind one of coveys of partridges. That spectacle grew familiar on the Western Front; it was born of the change and progress in war.

Speed, too, was born of the unforeseen needs of the war, and supplied by engines of a horse-power not contemplated by practical minds till the fighting aeroplane suddenly developed. In the summer of 1916, when we were at length getting uppermost in the air, the head of an aerodrome in France told me

[1] Nevertheless heavy wind and squally weather remain a great impediment to artificial flight and often a peril. I do not write as an expert; quite the contrary. But for some years I made a rather close study of the flight of birds and insects, and I was powerfully impressed by their frequent difficulties in rough weather. Some of our land birds, among them the fleetest of the hawks, are baffled by very heavy wind; and others appear at times confused and even scared by it. I have seen the kestrel half stupefied by it.

he believed we might ultimately reach a speed of almost 200 miles an hour as maximum. It is by no means certain that this is impossible ; that is, a pace which may exceed the speed of any bird or insect. There is no accurate knowledge as to the rate of birds at their maximum. Gätke held that, on migration, even a bird of moderate speed, like the blue-throated warbler, reached up to 180 miles an hour. His theory is disputed ; and certainly it appears that neither Alpine swift nor our own species travels at such a pace. On the other hand, I incline to believe that the rate at which birds, even small birds, can travel is often understated. An aeroplane enthusiast, who is much interested in birds, tells me that he has noticed that various birds will often completely surpass, at least for short distances, a very powerful motor travelling at high speed. He has particularly noticed the yellow-hammer of the roadside hedge in this connection when he has been motoring. The marvellous feature in bird flight is the ease of the start and the amazing rapidity with which speed is gathered : that, I think, we shall never rival in our artificial flight.

It is easy to exaggerate the potentialities of air-craft in war, to predict that the airman will take the office of the infantry and fight the next war wholly in the air. That is the foible of those who completely overlook the fact that defence against air attack grows as the offence grows. Early in the war we were powerless against airships, late in the war they were almost powerless against us. Early in the war an aeroplane was only rarely brought down by gun-fire—at a height of about half a mile the aeroplane was safe enough then—but in 1917 and 1918 the defence against aeroplanes distinctly progressed,

though not at the rate at which the offence progressed. Towards the end of the war the aeroplane was by no means immune from the fire of the "Archies," even when it was three miles high. It is true that a vast deal of ammunition must be expended from the ground on bringing an occasional aeroplane down. But it is equally true that a vast number of bombs must be expended by the aeroplane in bringing a city down. These little points are overlooked by the credulous and by those who see "red" wherever air-craft is concerned. But they are worth considering.

The aeroplane is certainly a terrible and swift arm of modern war. Why exaggerate its powers?

In 1914 its province was reconnaissance; and on the whole reconnaissance and observation, possibly even during battles, remained the most valuable, though bombing and machine-gunning came to be immensely important functions. In a later chapter I shall touch on optical munitions. How valuable was that industry to the air force is emphasised by figures concerning photography from the air. To attack the entrenched enemy with any chance of success, we had to know the position of his strong points, his machine-gun emplacements, "pill-boxes," redoubts, trenches. That knowledge was largely secured through photography by aerial observers. The first successful photograph was one of Neuve Chapelle taken in 1914. Photographs could then be taken within half a mile or so of the ground. When the anti-aircraft gun grew formidable the observers were driven to far greater heights. Ultimately by means of powerful cameras observers could take photographs at three miles height and even more. At the beginning of the war they rarely

mounted to half that height. Our optical glass industry was kept busy with the manufacture of large numbers of powerful lenses; during the war over five and a quarter million prints of aerial photographs were issued in the field, taking all the fighting fronts. During the last full month of the war, October, the Air Service in France exposed over 23,000 negatives and issued 650,000 prints. The excellence of our trench and other army maps was ensured by the optical munition-makers at the base, such as Ross's.

At the start aeroplanes observed, they did not fight. A few German aeroplanes carried machine-guns. The pilots of ours had at most a rifle or Winchester repeater. They might perhaps as well have carried an umbrella. In September 1914 a gun for the first time was fitted to a British machine, and later the arming of aeroplanes with Lewis and Vickers guns became general for fighting purposes. The history of the Lewis machine-gun used by the Army and Air Service during the war is interesting. The forerunners of the modern machine-gun were the American Gatling gun which was used so far back as the war between the North and the South, and the mitrailleuse or *canon à balles* in the Franco-Prussian War of 1870—an ill-fated weapon, whose secret was hoarded so closely that when it went into action hardly anybody knew how to use it. The possibilities of those weapons stirred the imagination of inventors—of Nordenfeldt, Gardner, Hotchkiss, Maxim, and Colt. A great deal of money and material was spent in the endeavour to produce an automatic apparatus for loading and firing, and for ejecting the empty cartridges. In 1883 Sir Hiram Maxim easily

passed all competitors. He invented the Maxim machine-gun, which could fire 600 shots a minute accurately; and after Omdurman his weapon was adopted by the European Armies. It was not of much value in the South African War; in the Russo-Japanese War it had successes and failures.

Yet, though the value of the machine-gun was freely acknowledged, Germany alone among the Powers adopted it in large numbers. France, in comparison, was behindhand, whilst we restricted ourselves to a paltry total of machine-guns to a Division; such an arm as the M.G.C., as I have mentioned elsewhere, was not even mooted before or at the beginning of hostilities.

The Maxim did great execution against the Arabs at Omdurman, but there was room for improvement in the mechanism. It is somewhat heavy, and failures occurred through its jambing in hot actions. Two years before the war Colonel Lewis of the United States Army brought a new design to Europe. A syndicate was formed, and the manufacture of his gun was entrusted to the Birmingham Small Arms Company. A capital arrangement was the cooling of the gun by air instead of water, which substantially reduced the weight—the Lewis gun is scarcely more than three times that of the Lee-Enfield, which it resembles in many of the machining operations. The air currents which keep the gun cool, even when it is firing at the rate of 700 shots a minute, are set up by the gas blast, and the process is aided by the sheath or jacket of aluminium in which the barrel of steel is encased. Aluminium is a far greater conductor of heat than steel; and by the clever manner in which the two metals are combined the heat engendered

by rapid firing is easily carried from the steel to the aluminium, where it is thrown off by the continuous draughts of air. The Lewis gun can fire up to 700 shots a minute; the Vickers can reach 1000. Neither these nor any other type of machine-gun superseded the rifle during the war. It may be that machine-guns never will do so. But they were, on earth and in air, tremendously powerful weapons both in attack and defence. The Germans used them all through with skill, and it was largely owing to machine-gunners that in the last weeks of the war the retreating Army did not become a disorderly rabble.

In November 1913 the Lewis gun was tested from an aeroplane at Bisley. The wind at first was high, and much manœuvring was necessary before the gun could be brought to bear on the target, which was a sheet laid on the ground. In those days artificial flight was barely practicable in high wind. Yet the target was hit many times at heights varying between two and five hundred feet, and the gun was fired successfully upside-down as well as sideways. As a result of this test, the British Government and foreign countries adopted the weapon. There is the minimum of recoil in this gun, an advantage due to the gas operation; and it is even possible to fire the gun held at arm's length in the hands. In two and a half years the Birmingham Small Arms Company managed to get together 10,000 machines for making the Lewis gun, which were run by women as well as highly skilled mechanics. There is a great deal of refining work, as with the service rifle, in the manufacture of some components of the gun. The body of the gun for example is shorn down from a weight of nearly 19 lbs. in its forged state to about 4 lbs. in

its completed form. In 1918 there was a movement in favour of a Danish machine-gun type—the Marsden. But, after a series of trials at Bisley, the Lewis gun was preferred to the Marsden and various other competitors, the light Hotchkiss being placed second in the order of merit.

The German Fokker aeroplane was formidable in no small degree, because the airman could fire his machine-gun through the revolving blades of the propeller. Mr. G. Constantinesco took up the problem here, and patented an invention which enabled our own men to fire up to 1000 rounds a minute, through the propeller's revolving blades, from the Vickers gun. This marvellous synchronising gear was invaluable. The British Thomson-Houston Magneto Makers contrived a testing-machine so that our aerodromes were able, when desired, to test the relative position of Vickers machine-gun shots to the propeller blade; and several hundreds of these machines were ordered by the Air Board.

After the adoption of these machine-guns for aeroplanes there were various improvements in the way they were mounted, the object being to bring the weapon easily into the best position for shooting. The development of the fighting side of the aeroplane was one of the romances of the war. The dreamer of "Locksley Hall" was a finer prophet than any the European War has justified—though he never had an opportunity of proclaiming "I told you so!"

The aeroplane engine was one of our very early perplexities and alarms.

It is wrong to represent that on war breaking out we sat with folded arms as regards aircraft engines and did nothing till the munition fervour of 1915

seized on the nation. It was not so bad as all that. I see no sense in representing everybody at the War Office as a sluggard or dolt. It is foolish: and does not help us to understand the munition movement. On August 7, 1914, three days after the declaration of war, the problem of the engines was being taken up by the War Office. Most of our few aeroplanes had been fitted hitherto with French engines, the Gnome or the Renault with their modest horse-powers. The Gnome was the engine introduced at Rheims in 1909—a light type improving greatly on its predecessors. An arrangement was promptly made in August 1914 between the Gnome Company and the Daimler Company for the construction of the engine here; and by September 30, 1914, the English company managed to complete its first aeroplane engine for the Government. True, it was an unpretentious thing, with its 80 h.p., compared with those which were to follow; for high speed and great climbing and lifting powers were not yet features of war flight. Nevertheless, to turn out one of these engines meant the making of over 1100 different parts. The drawings had to be prepared; the dies for the various stamping of the tools, jigs, and gauges had to be made or procured: all in a desperate hurry. Fortunately for those early pioneers, there was not the fierce competition for material which was to arise later.

A second type of aeroplane engine, the R.A.F.1, designed by the Royal Aircraft Factory at Farnborough, was undertaken by the same company whilst work on the Gnome was going forward; and now the War Office, intent on a large output of aeroplanes, was issuing contracts to various firms. It

became necessary for manufacturers in this great rising war industry to pool their trade secrets and brains for national purposes. After a time, it was the policy of the Government, in order to simplify the problem of supply, to place new contracts simultaneously with a group of firms.

The manufacture of aircraft engines is an instance, like that of magnetos, of the creation of a new industry in Great Britain. We started with nothing, and were helped, I believe, by a French supply of between one and two thousand. Between March and the end of December 1917 our output was 13,979 engines; in ten months of 1918 it was 29,561. The complete figures for the years 1915 and 1916 seem to be wanting.

We not only built for ourselves, we built for our Allies. France had made engines for us; we made engines of different types for France before the end of the war. Also, we supplied to France and Italy Hythe gun-cameras; and to Italy over 2000 Vickers and Lewis guns for her aircraft.

In 1915 the nation had to make munitions wherever it could. There was no picking and choosing. Sometimes we had to make them in ill-lit, ill-ventilated, dirty, overcrowded places into which sunlight scarcely penetrated. It is idle to overlook that. Those were legacies of old, bad days. Peace has her victories—but peace has had her industrial horrors too; and they have often been quite as shameless and cruel as war.

It became, during the war, well understood that the nation, to get the best out of its producers, must see that the producers had good quarters to labour in. The State itself grasped well this truth. Therefore we found, scattered through the country, those grand

1918 national factories. One of the finest examples of this new and late war factory I saw was National Aircraft Factory Number Four, near Manchester.

"How did you make your aeroplane in 1913 or 1914?" I asked a pioneer worker on the assembly side.

"Oh, we had to get it together somehow anywhere," he answered; "a bit here and a bit there, as best we could."

"Where did you assemble the different parts?"

"We didn't; there was no assembly, so we couldn't."

In fact, an aeroplane then was "somehow got together." In 1918 the assembly shop alone covered five to six acres of ground. Sunlight poured into this lofty, airy building, which was kept warm by a great overhead pipe. There was space to breathe, move, and strive in to good effect. It was a world away from the dingy, depressing workshops common in the past. The war brought the nation more benefits than the nation yet knows. The type of factory built by the State near the close of the struggle was one of these.

The aeroplane, virtually the whole of it, was made and put together in the State factory. Except for engines, guns, and scientific instruments, such as compasses, air-speed indicators, altimeters and revolution counters, everything was created on the spot. The aeroplane started in the rough sawmill. Here the work was heavy, and reserved for men who rough-sawed the silver spruce, Oregon pine, walnut, and ash to the thickness, length, and breadth needed. It passed to its second stage, the conditioning shed, where, through the correct mingling of air and warmth,

the excess moisture was taken out of the wood. About 15 per cent of moisture was left in, and the material then passed on to the finished sawmill to be smooth-sawn and planed. Here the women workers begin to appear in numbers.

Attached to the finished sawmill was the glue room, where the laminating was done. The demand for aeroplane wood, especially silver spruce, became in the later part of the war so great we could not get enough whole planks for the chief part of the framework which bears the weight. Therefore we had to adopt splicing; then laminating. Several sections had to be fine-sawn, planed perfectly smooth, and glued together under pressure in an even temperature. This is laminating. A laminated spar was found to be at least equal to a solid spar. Curved surfaces of the fuselage, for instance the cowl which encloses the pilot and observer, are beautifully wrought together by very thin sheets of wood with the grains running in opposite directions. The result is strength, flexibility, lightness. The propeller is built up in the same way, strength and flexibility being of very great importance there. The German munition-makers were even more pressed for wood than ourselves. They resorted to metal, and their A.E.G. bomber was largely metal made. We were experimenting on it towards the close with a view to using it for our training aeroplane, the Avro, which, according to Lord Weir, was absorbing something like a third of our wood supplies.

Next to the finished sawmill, one reached the metal room, with its presses, lathes, automatic machines, milling and drilling machines; tool-makers, sheet-metal workers on petrol tanks, pipes, cowls.

Here again the women were at work, brazing, welding, enamelling. There was a final inspection in this room which closed all the detailed manufacturing work, both wood and metal.

Crossing to the other wing of the factory, one reached the assembly. In this grand room all the manufactured parts of the aeroplanes were put together. Here, too, the fabric was stitched by hand to the wings, tail planes, little wings or ailerons, elevators—woman's work all of it. Every stage of fitting it for the air added something of interest and beauty. How the old writers on flight, Leonardo da Vinci and his followers, would have exulted in this sight, the wonder of it growing and growing from step to step under the fingers of girls who, till a few months ago, had never been inside a factory let alone a factory of flight! The fabric having been stitched on, the wings are made taut and weatherproof by dope—still woman labour.

In the assembly room all parts of the aeroplane were arranged in their exact sequence. You walked down the long lanes of this room, and there was the aeroplane being step by step built up—planes, struts, tracing wires, wings, tail, rudder, fuselage, chassis; its exquisitely fine materials of wood and steel and cloth being fast knit together, taking coherent shape and form; till, finally, there before you was the complete, wondrous thing, even to its wooden propeller—a triumph of strong yet delicate miniature work. Elaborate pains and curious study had been spent by hand-workers and brain-workers—for an aeroplane is compact of brains—on all manner of fine detail. The success of the pilot, the life of an "ace," might hang on a thread, on some trifle of a fine wire or tiny pin.

Take, for example, the rod used for the internal diagonal bracing of wings and fuselage. Its fork end is attached to the wiring plate by an ordinary-looking pin. Yet the steel of that pin, before it can be accepted, must pass the test of a pressure of 90 tons to the square inch; whereas average steel needs only an ordeal of a 30-ton pressure.

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When aeroplane construction was in full swing type succeeded type so quickly, and the variations were so numerous, that only experts in design could keep pace with them. There were starred machines, for a time on every one's lips. There was the S.E.5, a fighter credited with having brought down more enemy machines than any aeroplane during the war; a single-seater designed by the Royal Aircraft Factory at Farnborough and fitted first with a French Hispano water-cooled engine, later with a Viper, 180 to 200 h.p. It was a development of the B.S.2a, with which we started the war. The Snipe, a single-seater, built by Sopwith and fitted with a 200-h.p. air-cooled engine, was famous as a fighter too. Captain Barnwell's Bristol fighter appeared early in 1917. This was a two-seater, which might be described as a reconnaissance machine, particularly apt in self-defence, and fitted with a Rolls-Royce engine.

The B.E.2c, a two-seater, came in for a great deal of notoriety of another kind. It was described as "fodder" for the German Fokker. It was certainly not apt in self-defence, though the losses through it were probably light compared with those we suffered in machines at the Battle of Arras in the spring of 1917. But the truth is the B.E.2c was for artillery observation; it was not a fighter at all—

and the Fokker was. The Fokker was not the marvel it was pictured. Much of its success seems to have been due to the development of a new method of attack, and to the synchronising of the trigger of its machine-gun with the propeller, which we had not then adopted. Otherwise, the Fokker, a single-seater aeroplane with a rotary engine copied from the Gnome, was not, Lord Weir has pointed out, markedly a better machine than our own B.E.2c, with which it so often fought in 1916.

There was during the war a good deal of criticism of this Fokker kind, not always very close reasoned but due to natural excitement. Clearly, machines intended primarily for artillery observation, or photography, or other special functions, could not either on our side or the enemy's excel if they came to blows with aeroplanes out for naked fighting.

There were many other striking types which " had their day and ceased to be," or evolved into new forms as the war went on. The Pup, a Sopwith machine, was a single-seater with a small but good French engine. This machine lasted for some time, despite its small horse-power engine—80 h.p. But when fighting skill in the air grew it was superseded by the Sopwith triplane with an engine of 110 to 130 h.p. Later came Mr. Hawker's design, the well-known biplane, the Camel, armed with two guns, and driven by an English engine of 150 h.p. It was manufactured in great numbers in Great Britain.

The Martinsyde F.4 was the last word in war construction, though, coming out at about the time of the Armistice, like the tank Mark VIII. it never went into action. It had a Rolls-Royce engine of 275 h.p., was capable of a speed of more than 130 miles an

hour at a height of 15,000 feet, and could climb that height in 12 minutes.

The $1\frac{1}{2}$ Strutter (Sopwith) was a notable machine in 1916. It had an engine of 130 h.p., and was a very good fighter; the observer working his Lewis from a rotatable gun turret behind the pilot.

Finally there were the later bombers, day and night, long and short distance, great improvements on the machines casually used for the purpose early in the war. Systematic bombing was first carried out on the British Front by the B.E.2c. Martinsyde and De Haviland developed the bombing type. Captain de Haviland, of the Aircraft Manufacturing Company, was early in the field with designs that united high speed with long-range weight-bearing in the bombing machine. The Handley-Page made night bombing a practical proposition. It was fascinating in the summer of 1918 to watch these machines practising from an aerodrome in the English countryside—sometimes night after night in fair weather.

We could no doubt have done with a lesser number of types, though six at least would in any case have been always necessary for the various rôles of day-bomber, night-flying machine, artillery observation, and so on. The multiplicity of variations, one succeeding and displacing another as the war went on, was due largely to the individualities of different constructing firms and the healthy competition among them to produce a machine better than the last one. But it is a question whether, despite the great strides made in climbing, speed, etc., the efficiency of the aeroplane itself, considered apart from the engine, greatly improved during the war. In November

1918 it still needed about the same horse-power to lift a given weight of aeroplane that was needed in August 1914. Aerodynamically, the efficiency of the machine had not markedly improved during the war. The improvement in flying powers, above all in the quickness of climb which was a clamant necessity, was very great; but it was the engine mainly that did it—there the progress was extraordinary. We found in this fierce race for life in the air that we got quicker results by concentrating might and main on the horse-power side of the problem. So the engine became the solution. Research, now that strain is over, may well prove there is room for progress in the design of the machine itself. It would not be economy, it would be blind extravagance and reaction were the nation to abandon research because the menace of world war has—conceivably—disappeared.

Almost from the start of the war the Germans, foreseeing the importance of large and very powerful engines, concentrated on the production of a single type of motor. They proceeded to standardise the design, which was distinctly an advantage, in the early period, though later it may have proved a hindrance to progress, We in those days preferred to work on a number of types, air-cooled, water-cooled, 8-cylinder, 12-cylinder, and so forth; and it is certain that, before the close of the war, we had outstripped all competitors; we ended up with the best design and the largest supply.

I have shown by various examples how long it takes to produce shells, guns, and rifles on a large scale, when we have to start by building and equipping the workshop and training and organising the labour. Nothing much is possible under a year. It is not

till the output fairly begins that the process becomes comparatively simple: then the thing takes charge, and we speedily get our bulk. More than a year must elapse, ordinarily, between the stage when a new aeroplane engine design is taken in hand and the stage when that engine can be produced in bulk. Indeed, Lord Weir, in a masterly lecture on aircraft design delivered in July 1919 at the meeting of the Institution of Engineers and Shipbuilders at Newcastle on-Tyne, put the period of gestation at eighteen months. "During most of this period no useful practical experience can be obtained as to the qualities or defects of the new designs, and by the time bulk experience of its behaviour is available, it is necessary to supersede it by another more advanced type. Less than half the time for the development and trial of an aeroplane design, so that the aeroplane is generally well ahead of the engine for which it is designed."

In manufacturing aeroplane engines, magnetos, guns, machine-guns, shells, gauges, and many other kinds of munitions, one thing was uniformly in our favour—the long-drawn-out character of the struggle. Many people prayed for a short war: that would not have been a merry one for us.

In regard to engines and machines, there have been many stories as to what we were going to do to Germany and her Armies, when suddenly the Armistice closed the fighting. Some of these have been exaggerated. But in November 1918 we were much further ahead of the Germans in regard to aerial offensive than they were ahead of us in August 1914. We spent money with both hands in research and in the scrapping of material during the latter part of the war, in order to beat Germany in

the air. In doing so, we forgot all about commercial propositions; and we were right to forget all about them—it was, well understood, economy to forget. As a result of this large—and wise—expenditure we had at the end of the war three types of machine, besides the Martinsyde already referred to, which promised highly interesting results militarily. These are worth mentioning:

First, we were ready with a machine called the Salamander. It was built by Sopwith, and was a single-seat fighter with two Vickers guns. The Salamander, designed for ground fighting, carried a large quantity of ammunition. The pilot and vital parts were protected by armour-plates against armour-piercing-bullets. No such ground fighter had hitherto taken the air; and, despite its heavy load, the Salamander had a maximum speed of 125 miles an hour.

Second, we had a less sensational but perhaps equally useful machine in the shape of an armoured two-seater, especially designed for co-operation with the infantry, a practice which was coming to the fore in the last stages of the struggle.

Third, there was the Handley-Page which was to try its fortune on Berlin—450 miles from the base of the machine in England. It was to carry a crew of seven, besides guns, ammunition, wireless apparatus, and—THE bombs! Four 350-h.p. Eagle Rolls-Royce engines were to be employed to convey the giant. The first of these aeroplanes was built—and built quickly—in Ireland. It was just ready for operation when the Armistice was granted.

Finally, we were laying our plans at this period for getting over a difficulty which hitherto neither we

nor the enemy had tackled successfully: that of preserving direction accurately whilst flying through heavy clouds or fog-banks. At the end of the war we were systematically training pilots in the use of the aeroplane compass based on the design of Keith-Lucas and on the instrument known as the turn-indicator, by which the airman would be able to keep his sense of direction in cloud or fog.

Altogether our air offensive for 1919 was distinctly promising. We can agree about this without reaching a decision as to whether or not it would in a few hours have "laid Berlin in ashes."

CHAPTER IX

KEY MUNITION INDUSTRIES; AND THE WORK OF SCIENCE

It has often been proclaimed that the war was "an engineer's war." Statements of that kind, as I have said elsewhere, are unfair to the fighting man. They are only superficially true, though not such indecent travesties of fact as claims that this or that sailor, statesman, or soldier "won the war"—or would have won it in six weeks if he had been allowed to land a force somewhere in the Alps or the Baltic. The engineer played a great part in the struggle, but so did the man of science. He was indispensable to the creation of certain key industries which we tackled at the start. I suppose, however, it is hardly possible to name a branch of munitions in which scientific research and ingenuity were not active from the start to the finish. The chemist was at work at front and base. The history of British Science engaged in offence, in defence, and on the medical side between August 1914 and November 1918, if ever it is written in detail, will fill many a volume. The public knows little of that wonderful output of brains and devotion. Only a few of the more sensational or curious inventions due to scientific research, such as paravene and depth charge, gas and gas-mask,

have been generously talked or written of; whereas the fact is that the improvement of all manner of existing weapons of offence and defence and the creation and evolution of new weapons were the result of work in the laboratory before the munition factories could produce in bulk. One reason why so little was known of the work of the scientific men lay in the secrecy that during the conflict necessarily veiled it; another lay in the difficulty and obscurity of the subject to the untrained mind, for most of the research work does not allow of popularisation.

Among the bodies engaged in war work were the Universities of London, Oxford, Cambridge, Leeds, Sheffield, Glasgow, Edinburgh, Bristol, St. Andrews, Durham, Manchester; the Imperial College of Science and Technology at South Kensington, the Royal College of Science for Ireland, University College at Cork, Queen's University at Belfast, the Lister Institute, the College of Technology at Manchester, University College at Nottingham, Rothamstead Experimental Station at Harpenden.

To select a very few of their tasks over the whole field of war: The University of London—at East London College—had begun to study the problem of the detection of submarines in the summer 1915. The experiments started in a pail of water; thence they were carried, successively, to the laboratory sink, to a swimming bath, to the Elstree Reservoir, finally to the open sea on the Scottish coast. A directional electrophone took form out of these investigations, and was largely used before the close of the war. The Electrical Engineering Department of University College itself was also studying the problem of under-water sounds by hydrophone in

the Hampstead Ponds. The Imperial College of Science sent Professor Baker to France in 1915 after the second Battle of Ypres to discover the nature of the gas used by the German Army, and to devise methods of protection against it. The gas was identified and a protective solution against it worked out at St. Omer. Then Mr. Baker discovered that it was possible to increase greatly the solubility of the two salts used in the British gas-mask, which gave a much better protection. Our chief Allies adopted this improvement. Soon afterwards, the Germans tried another poison gas—phosgene—for which no quick absorbent was known. But, by the time this gas was introduced, the Imperial College had discovered in the laboratory an absorbent which protected our troops against the new threat. The same College was also, in union with the Trench Warfare Committee, busy working out in the laboratory a gas for British offensive purposes. For two years most of the chemical investigations were made at the College, which also worked for the Anti-Gas Committee at the War Office.

One branch of the University of Manchester was experimenting in 1915, long before the unrestricted submarine campaign started, in devices for destroying submarines. It produced depth charges which were useful as types for later construction. Cambridge employed itself in devising apparatus for timing and dropping bombs from aeroplanes, in improving the compasses for aeroplanes, in designing non-rigid airships and anti-aircraft gunnery, and was investigating that wonderful thing the location of sound which gave invaluable aid to the gunner in war. It was developing range-finders for anti-aircraft purposes—

and was studying methods for the protection of kite balloons against lightning! The researches of the University of Bristol in regard to the principal lethal gas used by the British Army led to designs for its manufacture on a great scale. An Oxford man of science, Major Lambert, having discovered a certain absorbent of poison gases, invented the mask which developed later into the box respirator used by the British Army.

Various universities and scientific bodies devoted attention to the improvement of aircraft during the war. The aeroplane engine with its complex parts, "the form of the struts and planes, the covering fabric and the varnish applied to it, the recording instruments, the photographic gear, the signalling apparatus, the machine-guns, the bomb-dropping arrangements, each of these has been the subject of experimental research requiring the highest experimental skill. Each was improved beyond all belief during the war. By how much labour and devotion, only those intimately connected with it can tell" (*Nature*, April 24, 1919). "So too with the brigade of chemists . . . the manufacture of explosives required the solution of chemical problems which they accomplished, and so saved the nation vast sums of money. . . . They produced the smoke-screens and the special bullets which brought down Zeppelins and observation balloons. . . .

"A body of keen young physicists drawn from various universities of the Empire developed the methods of sound-ranging till it became possible to locate with extraordinary accuracy the positions of enemy guns even during the continuous roar of the Western Front; they were responsible for a great

part of the locations on which artillery work depended." I remember visiting one of the places—at Arras—in the summer of 1916, where these exquisite observations were being made, and a practical gunner telling me soon afterwards what faith he reposed in them for carrying out his task on the Somme of finding and attacking enemy guns.

The men of science in these universities and colleges were not only investigating with a view to others inventing munitions, or themselves inventing munitions; much of their time was spent in test-work, passing or rejecting completed implements before these could be despatched to the Front. Notably among these were high-grade gauges and optical instruments for Army, Navy, Mercantile Marine, and Air Service. Men of pure and applied science in several of our universities [1] devoted themselves to the second of these key industries of war.

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Optical Glass

Optical instruments made one of the most interesting and unexpected adventures in the munition movement. To get our optical instruments, we had not only to build a new British industry, we had to create abundantly the essential material out of which they are produced. It is true there were brains in the country long before the war that understood about optical glass and scientific glass-ware. Also, there was one firm, the Chance Brothers at Birmingham, that for over sixty years had striven to supply the

[1] The National Physical Laboratory and the Imperial College at South Kensington worked on the formulas for optical glass and discovered many of them after experimenting for some weeks.

nation with this glass. But we did not avail ourselves of those brains and did not encourage the pioneer firm.

Soon after the war started, there was an imperative demand for field-glasses—and that was about all the public knew about the famine in optical instruments which in war are the very eyes of the soldier, the sailor, the airman.[1] Lord Roberts appealed for field-glasses, and there was a sort of "Old Contemptibles" campaign in the optical line. The response to his appeal was magnificent, but it was not war—on a Continental scale. Moreover, it had nothing to do with industry.

Early in 1915 we were perilously short of nearly every kind of optical instrument of precision. Most people talked of shells and guns. But those behind the scenes knew that, without glass, even shells and guns in vast quantities could not avail us; and, virtually, we had no glass to make the instruments out of. We were at war with the nation which had long been selling us the great bulk of the implements, military and scientific, which we now needed.

Looking back at that period, early 1915, there is something ludicrous about our position. Yet the thing was nearly tragic. Leaving chemical glass out of the question—though it is of highest importance for medical and scientific purposes, and the production of it in this country was a vital war necessity—let us take a few of the numerous optical instruments of precision which, in 1915, the Army and the Navy wanted in large quantities. Between them, the Services wanted, for instance, telescopes, periscopes,

[1] In reply to a question in the House of Commons the Government admitted that there had been "some difficulty" in procuring "a sufficient supply of optical glass" for war needs at this stage.

field-glasses, photographic cameras; without cameras the air service, then coming into prominence as an indispensable arm of war, would be robbed of half its utility.

The artillery wanted range-finders, directors, sighting telescopes, dial sights, clinometers, angle of sight instruments; without these, the gunner and the observer would be about as helpless as a gun without its breech-block.

Except for range-finders—one of the few instances in this glass industry in which home ingenuity had been advanced by home interests—we could not satisfy the pressing demand of Army, Navy, and Aircraft for these and many other optical instruments. There was no industry to meet it. Even the relatively small demand before the war for the glass required in these instruments was met by a home supply only to the extent of 10 per cent. France sent us 30 per cent, Germany 60 per cent—and France had now her own urgent and growing war needs.

The Germans had long since developed a great optical-glass industry at Jena. It was encouraged by their Government, stimulated to excellent research work, and aided by a State grant. This grant was not large, but Jena found a sure market through the great military establishment of the country. The industry flourished and was able almost to oust France and our solitary pioneering firm, the Chance Brothers of Birmingham, from the British market. It could afford to experiment in various directions—Dr. Abbé, aided by Government subsidies, did invaluable research work for the German trade—and it discovered and produced with commercial success new and valuable types of optical glass. So that by

August 1914 Jena's position seemed impregnable. Zeiss glasses had become quite an obsession here. We could not imagine anything British competing seriously against such instruments. Zeiss, before the war, had a scientific staff of twenty men of the standing of University Professors.

That was the situation when we were faced by a long and tremendous struggle. But absence of the instruments, and of factories and skilled hands to make them, was only part of our difficulty. The other part consisted in the fact that we had not in any quantity an essential ingredient of optical glass, namely potash. Potash is to various forms of optical glass what sand or clay is to bricks. Germany had developed a world monopoly in potash. Her Stassfurt mines were controlled and protected by the State. In 1913 we imported £1,380,567 worth of potash salts for various industries, and £915,867 worth came from Germany alone.[1] Our only other source of importance was France.

With the German market closed to us at the outbreak of war, we were reduced to a few subsidiary sources; and on these the agriculture and dyeing industries, besides various lesser ones, such as soap and matches, had their claims. It is hard to imagine a more hopeless position, as regards these military and naval instruments of precision, than we were in when the Ministry of Munitions was set up in 1915. Even some of our indefatigable scientific workers and optimists could not see light.

And what was the position in October 1918? The answer is that we had invented a process for

[1] *The Board of Trade Journal,* "British Supplies of Potash," September 5, 1918.

obtaining the potash, and were producing per annum about ninety times as much optical glass as we had produced in 1913. As to types: we made eleven different varieties of optical glass in 1913; we made seventy-five different varieties in 1918. In short, Great Britain had at the close of the war an optical glass industry able to meet henceforth the entire demands of the Empire.

How was this extraordinary change brought about? Where was the potash found, how was the research work carried through, and where did the skilled labour come from? Enthusiasm, devotion, science, and organising skill brought it about. It would be impossible to say which of the four deserved the palm; as a fact they were all wrought together into a perfect working whole, which saved a perilous situation.

Three names have to be mentioned, if the work is to be well understood—Esslemont, Chance, Jackson: organiser, pioneer manufacturer, scientist. The Glass Trinity.

When in 1915 the optical munitions and glassware department of the Ministry of Munitions was set up, the late A. S. Esslemont was appointed Administrative Director. There was a dearth of highly skilled labour, not a few even of the small number of trained men in glass work having been taken for the Army, and the question was how were we to fill these gaps, and, additionally, to find others adequate to the demand? The making of optical instruments demands skill and intelligence above the average war factory level. How could dilutees be expected to succeed in such an industry, when time and speed were of the essence of the problem? But Esslemont drove forward irresistibly. He would not hear of

insurmountable obstacles. He regarded "It can't be done" as old-fashioned nonsense — and said so. He brought together his manufacturers, organisers, and men of science. He kindled them with his own enthusiasm, and in an amazingly short time the industry had started and was producing.

A vocabulary of the optical and allied instruments for which the Optical Munitions Glassware and Potash Production Department was responsible in 1918 ran to twenty pages. It included binoculars,[1] for day and night use, periscopes—artillery, infantry, giant, magnifying, reflecting, trench howitzer,—cameras, lenses, telescopes — gun sighting, garrison, field artillery, micro, signalling, — sextants, compasses, range-finders—for artillery, infantry, coastal defence,—magnifying glasses, barometers, lamps, levels, height-finders, aeroscopes, clinometers; with many hundreds of glassware articles without which science must stand still and the medical resources for Army and Navy be exhausted.

Many of the instruments of precision we needed for Army and Navy were of a very complicated and difficult nature. To make a dial sight or a range-finder involves hundreds of processes, and five months' work might be needed ordinarily ere it could pass from the crude material to the finished article. Fortunately repetitive machinery, *i.e.* mechanical processes for turning out great quantities to standard, overcame our difficulties. Even so, the business cannot be

[1] We knew how to make binoculars, but not how to make them on a great manufacturing scale. A Ministry official went to Yorkshire and interviewed a cinematograph manufacturer who did not understand binoculars but did understand bulk production. He studied the matter for three months. Then he set to work and produced an excellent type of binoculars, and produced them in bulk.

rushed. Glass will not be turned out easily to sample, no two " melts " being exactly alike in optical properties. The ingredients may be mixed faithfully according to formula, yet the result will very likely not answer exactly to anticipation. Again, to estimate the precise curvature of a lens, or the relation of a set of lenses, and supply the optician with the design to which he is to work may take six hours in the case of a common telescope before the mathematical expert can complete his calculations. In regard to a microscopic lens it may take from a hundred hours upwards. One of our leading optical experts, in working out the path of the different rays of light through the whole system of lenses in the object-glass of a microscope, took two hundred hours.

The zeal of non-professional men in some instances helped us in optical instruments manufacture as in simpler forms of munitions. Graticules were wanted —the glass discs fitted into the eye or gun sights, etc. and marked with certain lines (usually cross lines) for getting direction. The German opticians, through a secret process, had got these lines very fine with corresponding military effect. Our efforts by comparison were rude. A City man, with optics as a hobby, set to work to discover how to get fine-lined graticules and by thousands. He examined the German graticule microscopically, experimented, and eventually found that the secret lay in a combination of photography and photo-etching. Then he turned out in bulk the graticules we needed.

In bulk of output the Optical Munitions Department was a small thing compared with the guns and ammunition side. But in most of those greater industries of war we had at least a fair nucleus to

start upon ; whereas in this very difficult and highly specialised one we can hardly be said to have had a nucleus at all ; and we were completely cut off, at the very outset, from our one important source of supply. We were in a far worse plight than was Napoleon in the French Wars, when he found that he could not clothe his soldiers except by smuggling into France British-made goods for them—which in his exigency he was driven to in secret. We could smuggle neither the instruments nor the potash without which they could not be contrived. We had, instead, to create a new industry.

As for the potash, Mr. Kenneth Chance and his fellow-workers found it—and that is one of the chemical romances of the war. A Potash Production Branch was formed in June 1917 by the Ministry of Munitions and a large part of its capital consisted in the results of experiments carried out by Mr. Chance of the British Cyanides Company and Mr. Lennox Leigh of the North Lincolnshire Iron Company. These experiments related to the production of potash as a by-product in blast furnace works. Research work was started in April 1915, but it was not till 1916 that direct experiments could be begun. After hard thinking and close work, Mr. Chance discovered that common salt introduced into the blast furnace would solve the problem. It had long been known that potash existed in the iron ores melted in the furnaces, but its release from them had not hitherto been regarded as a commercial or practical proposition. This simple addition of the salt removed the difficulty. Through certain chemical action, the potash chloride comes off in fumes and solidifies into minute particles. It is then extracted by technical processes from the

other fume dust; and it was found that the process did not injure the lining of the furnace or lessen the value of the iron. The method alone, it has been calculated, will yield us enough potash for our industrial requirements, of which, in peace-time, optical glass is a most modest item.

. . . . . .

To find the necessary labour to produce the optical instruments we had to scoop up what skilled or semi-skilled men we could, here and there, and to dilute freely with hastily trained women. The work of women in factories before 1915 bore no resemblance to the work they were employed on in munition shops between that year and the close of the war. The factory type, the appearance and character of the worker, completely changed. War work introduced into various branches of industry an entirely new class. It brought out latent intelligence which neither the girls themselves nor their employers dreamt of till dilution of labour was forced on the nation. Who before 1915 visualised servant maids as optical-instrument makers? Dick Swiveller's Marchioness helping some fighting brigadier to capture at a minimum of casualties a German "pill-box" or machine-gun post by a night storming party? Yet the thing probably happened again and again. The "pill-box" was exactly located in Flanders or the Hindenburg Line by a photograph taken from an aeroplane at a height of, say, 5000 feet.[1] It largely formed the material on which the brigadier arranged his attack. The eye of the camera that secured that minute, faithful picture was a powerful

[1] Early in the war the photographer worked at about 3000 feet. At the close he was working often at over 20,000 feet.

and finely finished lens. Who made the eye? Very likely a girl who, before the war, was engaged in the most prosaic household duties; and she may well have been, like Swiveller's Marchioness, the maid-of-all-work.

One may divide the main work in one of the larger optical-instrument factories into three parts. First, there was the steel work: this was reserved for engineers. Second, the brass work which was done by the instrument makers, who were also responsible for the assembling, whether steel or brass—for there was an assembly room in the optical-instrument factory as in the tank-hull or aircraft factory. Third, there was the glass-work.

The first lay outside the woman's sphere, practically, but she distinctly entered into the second, and was completely at home in the third. A gun-sighting room could be entirely run by women except for a supervisor and some men for the setting up of tools. Yet the gun-sighting telescope was not a particularly simple instrument, for irrespective of lenses, screws, etc., it consisted of nearly forty different brass parts. Subdivision of labour, repetition or the single purpose, however, enabled a woman with a few months' training to create a more complex instrument of precision than this.

But the woman's peculiar sphere was the room where lenses and prisms were made. In Ross's beautiful factory on Clapham Common the women in the glass branch easily outnumbered the men in 1918. Before the Ministry of Munitions set to work, this factory—one of the very few optical-instrument firms in the country which were running on a real manufacturing scale—employed 320 hands. All

were men, highly skilled. In November 1918, I found it employing 700 hands, including 120 women. The increase in the number of workers will be understood when it is said that this factory in 1914 made not more than five or six dial sights at most in a week, whereas towards the close of 1918 it was making sixty. For dial sights alone we were paying about £3000 a week to one firm. Germany put us to a heavy expense in munitions in the lesser as well as the great industries.

But, wherever one turned to in these munition factories, the same fact emerged—Germany unwittingly gave us invaluable lessons in industry; forced us to think scientifically; to originate, methodise, develop, and economise human and material resources, speed up all round in production on a manufacturing scale.

The bulk of lens and prism making was done latterly by women. The training took from three to six months. The manufacturing firms themselves chose and trained the girls, or the girls were put through their paces at such schools as the Northampton Polytechnic Institute in Clerkenwell. The optical-instrument work was above the average dilutee standard, and judgment was needed in selecting the right women for it. But at the start of the experiment we could not always wait to pick and choose. Sir Herbert Jackson told me he went to the North to see a new factory in 1917 which had been rushed into being the year before. He found it already going full blast, and women were at work on the glass. One of the first things he noticed was a very young girl polishing the lenses.

"You must excuse her if she is not yet very good

at it," said the manager; "she only came in at nine o'clock this morning for the first time." It was then eleven o'clock.

The work she was learning to do would in 1914 have been an expert glass worker's. Yet by these methods we were turning out instruments virtually equal to those of Zeiss.

The optical glass, after the material has passed through the pot arch furnace and been annealed—suffered to cool down slowly, or as slowly as the war would allow—reaches the instrument maker in slabs. It is then cut to the approximate size of the lenses and prisms required by a saw, the edge of which is notched by hand with a knife. Into the notches fine diamond dust is rubbed. These minute particles gradually work off and fall into a little trough of water, but the saw as it revolves picks up its diamonds and continues to cut with them, so that there is no need for constantly rubbing on to the edge a fresh supply. The sawn pieces are passed on to the girls, first for rough grinding, then for smooth grinding or polishing; after which, they are edged or precisely fitted for the instrument. They are stuck on to a block in pitch or plaster of Paris, several together, and are then ground by hand or machine with emery, and finished or polished with rouge, *i.e.* oxide of iron.

The whole process from sawing to edging is charming to watch. How delicate a work is polishing can be judged by the fact that, to ensure perfect flatness, it is usual to work to the fifty-thousandth part of an inch; whilst it is possible to work to the millionth of an inch. Such was the industry we had to create in a desperate hurry whilst we struggled for our life.

The Gauges

Behind the difficulty of the shells and guns in 1914 and 1915 was another, far obscurer and most embarrassing. We were not only short of the gauges in numberless different forms without which these munitions could not be made ; we were short of the implements and skilled labour for testing gauges—for passing those which were fit and rejecting those that were unfit. All manner of things may happen to munitions, say to the fuse of an 18-pounder, if the gauges have been untrue—and they will happen in favour of the enemy. Hence gauge-testing apparatus must approach something in the order of dead perfection.

The matter rested at the start mainly with Woolwich, but even so great an organisation as Woolwich was not by itself adequate to the whole burden when suddenly the gauge difficulty became acute. The State turned attention to the National Physical Laboratory, an offspring of the Royal Society, started in 1900. This Laboratory included various branches of scientific research work. It had, springing from its metrology branch, a modest twig budding out into the three things necessary for testing ordinary gauges, namely, apparatus, standards, and skill. Its staff of workers accustomed to gauge-testing consisted early in 1915 of five men all told. It had been in the way of testing, for purely commercial demands, perhaps a thousand gauges in a year.

Towards the end of 1917, this same institution was testing ten thousand gauges per week. Its record stands at thirteen thousand in one week of that year. The original staff of five had grown in November 1918 to two hundred—men, women, and boys.

Ordinary gauges need to be minutely accurate. But check gauges and master gauges, both the simple kinds and the complex and manifold ones, must be microscopically-minutely accurate. Two little instances throw some light on how meticulously accurate this master must be :

(1) Sweden supplied us in 1915 and later with sets of master slip gauges at £150 a set, each case holding about 80 small flat slips of beautifully finished and polished steel. Each slip has to be accurate to the one-hundred-thousandth part of an inch ; it has to be both flat and parallel within that order of measurement. I took up from a set at the National Physical Laboratory in 1918 two of the slips, removed from their surfaces all lubricant and moisture and laid one upon the other. Whereupon they became fast to one another, exactly as if they had attracted together by magnetic power. But the secret was not magnetic. It was this : the two flat surfaces of those steel slips were in such unimaginably intimate contact that they adhered to one another.

(2) These master slip gauges brought accuracy down to the hundred-thousandth part of an inch, which served our war purposes. But because they came from a neutral, with whom difficulties in a struggle might conceivably arise, and for other good reasons, it was felt that we should try for a home-made supply. Now to produce these slip gauges, trustworthy to a five-figure limit of accuracy, we had to go beyond even that limit in measurement. So that in 1918 we were experimenting, with good prospect of success, on apparatus which must respond to a six-figure limit. We must measure to something in the order of a millionth part of an inch.

Watching a woman engaged with the electric light on an extremely delicate task in gauge-testing, I said that she seemed to be nearing the infinite in littleness. "I don't know about the infinite," replied one of the staff, "but it looks as if we were getting near to the nought."

When the National Physical Laboratory started on war work it had to concentrate first of all on gauge-testing for six forms of munitions of which we were in urgent need. It had to test for the 18-pounder shell, the 4·5″, and the 6″; and also for a fuse, a gaine, and a primer, which the factories began making in vast quantities in 1915. Gauges for many other stores, submarine mines, aircraft, and so on, followed. That phase had passed by the autumn of 1918. Gauge-making and gauge-testing on a huge military scale had by then slowed down. But the work, both research and application, of the National Physical Laboratory has not been wasted. It has been fertile in new inventions, some of which are bound to prove valuable to future industry. Those are legacies of war to peace.

In the autumn of 1915 the National Physical Laboratory had to reject no less than 80 per cent of the screw-gauges submitted to it for test. By the autumn of 1918 it was rejecting not more than about 20 per cent; and this despite vast increase in the numbers of gauges examined.

Magnetos

In March 1917 a Committee on Commercial and Industrial Policy, with Lord Balfour of Burleigh, Chairman, reported on certain essential industries, and

recommended a post-war policy in regard to them. Among the industries were gauges—the screw and fine limit gauges—and optical and chemical glass. The Committee pointed out that, before the war, the making of these gauges was carried on as a distinct industry mainly in the United States and to a lesser extent in Germany, there being in Great Britain only one small firm engaged specially in their manufacture. Hence "great difficulties were experienced in meeting the very large demand for munition purposes." For optical and scientific glass, we were "virtually dependent upon Germany. . . . Since the outbreak of war it has been necessary practically to create the industries in this country from the foundation."

But there was yet another industry of vital war importance which had to be created after we had entered on the struggle—magnetos. Magnetos were "a typical example of what is generally known as a 'key' industry, because the supply of the article which is of great importance for all firing of motor cars, aircraft, motor launches, and stationary engines, was virtually monopolised before the war by the Bosch Company of Stuttgart."

In the summer of 1916, on a first visit to the war zone in France, I drove from Boulogne to Amiens one day, and for the first time fully understood that the war was being fought on wheels. Hour after hour as I left the coast, and later as I neared the Front, I passed motor transport of every description, often long lines of them almost as near one another as the carriages of a train. That meant magnetos. The war was then two years old, and we were producing the article. But the war had scarcely started before we discovered we must fight it on wheels; and those

wheels not horse but motor drawn. We had a motor industry of our own, and a good one, fortunately. It had to stand in the early days of the struggle an extraordinary strain. Long before tanks or tractors for gun carriage or workshops on wheels or anything of that advanced nature was thought of seriously, it was discovered we must have petrol-driven transport in great abundance, and motor cycles. Then came a sudden demand on the motor industry at home. Only a very small number of motor cars had crossed with the Expeditionary Force which was originally supplied with horse-drawn vehicles. The motor industry had to rush together all the cars they had in stock or were engaged on, and to start instantly on new ones. The Daimler Company, for instance, between August 7 and 18 had to make and deliver 60 new cars for the Army, and to follow these up before the Battle of Ypres was fought by 50 waggonettes. Limousine cars for the use of Staff Officers were called for in large numbers; also motor ambulances, 1000 of which Daimlers managed to produce in about the first year of the war. The huge motor tractors to haul heavy howitzers and guns to their emplacements, followed later in numbers—when we had the guns; travelling workshops, too, to be attached to trains of lorries, and wireless-telegraphy stations on wheels.

"It seems to me that the motor people are running this war," was a comment on one of those immense processions of lorries attributed to the Prince of Wales on one occasion at this Front. It looked like it at times. When we were moving north after the Battle of Messines in June 1917, preparing for the great thrust in the Ypres sectors, the roads were congested for hours sometimes by the lines of motor

transport. So that the magneto was truly a key industry in the war.

Before the war, something like 300,000 magnetos were imported into Great Britain, and of these about 90 per cent were supplied by the one German company. We had to subsist in 1914 and 1915 on what America could supply us with, and a stock of German magnetos which, by good luck, not foresight, we had laid in. The hold which Germany had on us is illustrated by the fact that the drawings of the magneto accompanying the War Office specification for transport vehicles indicated the Bosch product.

The story of the magneto, of our dependence on Germany for it, is as illuminating—and humiliating—as that of the optical glass; and not less creditable is the record of those pioneers who at once recognised the danger of the position and started to make good. There was even less excuse before the war for our humble dependence on Germany for magnetos than for our dependence on her for optical glass, as at any rate we had not within the Empire any considerable bulk of the essential war material potash for optical glass. We lacked the mines of Germany.

What was the situation in August 1914 as regards magnetos—which are to military transport what lenses are to optical instruments. Oddly, the situation as to home output was identical with that of the optical glass and the screw and fine limit gauges; there was a solitary pioneering firm producing magnetos—Thompson, Bennett at Birmingham.[1]

[1] Our position as regards the ignition plug, almost as important as the magneto, was not much more promising. We had at the outbreak of war three British firms manufacturing plugs, but the output was a paltry 5000 a year. In October 1918 we produced over 300,000—against 420 in October 1914—and our customers included France, Italy, and the United States.

The output of this firm was 1140 magnetos of a simple form. The high-tension magnetos which were to be turned out in Great Britain by tens of thousands for aeroplanes were unknown here in those prehistoric times. Here is Mr. Peter F. Bennett's account:

I happened to be on the way to Switzerland when the war broke out, but I went back to Eastbourne, and instead of returning to Birmingham at the close of the holiday week-end, I made a bee-line for Silvertown, and every fortnight, for the first eighteen months, I visited Silvertown to get mouldings. There was practically no high quality vulcanite for electrical purposes made in Britain. "Stabilite," the material used in the distributor, was an unknown quantity. They (the magneto experts) had to experiment with this material, and it took them many months to produce an efficient substitute. While this was being done, we had to make every moulded part out of solid vulcanite except the slip-rings. Another difficulty was with the enamelled wire. On a magneto there is first a primary winding of two or three layers of copper wire, covered with enamel, and above this a secondary winding of about three-quarters of a mile of very fine wire of the same kind. Originally this was a German production, and the manufacture in this country was in its infancy. Our difficulties have one by one been eliminated, as they can be eliminated when you intend to get over them. Little by little we managed to get the other materials which were necessary. Last of all, we had the difficulty which everybody has experienced, and which was particularly acute in a new industry—the shortage of proper machinery, and the training of butchers, bakers, and candlestick-makers to the work of making the magneto. We had been left very much to ourselves until July 1915, when the Admiralty Air Department put in charge a very live man to organise their magneto supplies. He chose certain firms, and he said, "I think these firms are worthy of Government contracts and support," and these firms since that date have made the majority of the magnetos used by the Air Service.

We started then to organise and to co-operate. With a lead from the Government you can bring manufacturers together more easily than when you have to do it on your own initiative, so we have got away largely from that idea of speaking with bated breath for fear that the other man may hear. We got together, and formed an Association of these electrical firms who were putting their heads together for the production of magnetos. We agreed, under the advice of the Government, as to how to allocate models and prevent overlapping.

We had numerous meetings in these early days. We standardised tests and assisted the Government in making comparisons and establishing a policy. Not only had we to educate our own labour, but we had to educate the Government Inspectors as to what they wanted.

The magneto, like all electrical systems of ignition, sprang out of the discovery of electro-magnetic induction made by Faraday in 1831. German ingenuity took advantage of that discovery, and of Lenoir's system of electric ignition devised thirty years later. Markus is described as the actual inventor of the magneto itself—as of the earliest petrol automobile—and in 1887 Robert Bosch of Stuttgart, carrying his experiments further, began to make ignition magnetos of a low-tension type. He applied for patents on his magneto in various countries. Another inventor in Stuttgart, Ernst Eisemann, patented a form of magneto in 1901 which was also in lesser quantities supplied to the British motor manufacturers.

Meanwhile British initiative had not been sleeping. Certainly three serious attempts had been made to compete against the increasing and eventually all-powerful monopoly of Stuttgart. But they aroused little interest or enthusiasm here, and they cost the

pioneers who financed them a matter of £100,000. Mr. Peter F. Bennett and Mr. Albert Thompson formed a small business in Birmingham for the production, first of the coil and accumulator ignition, and later of the magneto, when this grew in favour.

"But it was a heart-breaking business, and time after time we faced the position whether it was worth while going on."

These men were fighting exactly the same fight, not only against German push but British indifference, which the Chance brothers had long fought in the optical-glass industry. At the outbreak of war the Thompson, Bennett firm were producing only about twenty-five magnetos a week. None of these were taken up by the motor trade, but were used by makers of certain agricultural and marine engines.

Stuttgart ruled more supreme than Jena in a business which sprang out of an Englishman's brain, and ought to have gone to English industry.

Suddenly the German market was cut off. There arose an insistent demand for magnetos for cars, lorries, despatch-riders' machines, caterpillar tractors, tanks, travelling workshops, blower engines, winches for kite balloons, ambulances, and airships. The Air Service immensely developed after a year or so of war, and we needed a great number of high-tension magnetos of the finest make for aeroplanes. Magnetos for aeroplanes speedily became the most imperative of all, and the conditions of their manufacture were the most difficult and exacting of all. Great strain is put on the aeroplane magneto, both mechanical and electrical. It must be very strong yet weight must be kept down severely.

In peace it took Germany, with all her keenness and resources, years to establish the magneto industry. A few British manufacturers had suddenly in war to pool their energies and ideas, to thrust aside all the natural instinct of competition against one another and strive together for national ends. What they achieved was extraordinary. At the close of the war some fourteen firms were at work. In one year they supplied 128,637 magnetos for aircraft alone; and the complete total of magnetos for the year, including those used for land transport, shipping, and motor cycles, must have been upwards of a quarter of a million. In 1917 I watched a roomful of quickly trained girls working on different parts of magnetos in the Westinghouse factory, though magnetos there were merely a by-product.

The article produced, as by some conjuring trick of British industry, in the face of the greatest difficulties, was virtually quite equal to the best that Germany was turning out; our air forces could not otherwise have secured the ascendancy. Three were leading in this race, Thompson, Bennett of Birmingham, the B.T.H. Company and the M.L. Magneto Syndicate at Coventry, each producing various types of exquisite delicacy and fitness for aerial service. Every magneto manufactured had to pass through a series of the most searching tests before it was delivered to the air service. It had to be entirely dismantled after production, and its metal parts cleansed in petrol. Then it was reassembled and adjusted where necessary, remagnetised, run again for several turns, tested at low speeds to make sure the sparking was satisfactory, and finally overhauled in every detail. In the manufacture of the aeroplane magneto weight had to be

reduced to the utmost, and risk of fire strictly guarded against.

Besides the permanent magnet itself—before the war an absolute preserve of German industry—the magneto is compact of an astonishing number of different materials of which the purchaser ordinarily knows nothing. Thus, there go to its making, varnished silk, cambric and paper, ruby mica, tinfoil, aluminium and copper die castings, insulating baking varnish, Egyptian cotton tape, silk tubes of fine bore, ball bearings, carbon brushings, ebonite rod and sheet, etc. The silk is part of the insulating material used in the armature of the magneto. It is of very fine mesh woven in Japan, whither it is sent from the United States. We ought to make and weave it at home; and I gather from a paper presented in 1917 to the Aeronautical Society by Mr. A. P. Young that the British Empire is able to supply all the material used in the making of magnetos.

. . . . . .

Thanks largely to the length of the war, we eventually made good in regard to these three key industries in munition-making; and there were several others of very great importance which we managed to recover or create in time, *e.g.* the manufacture of high-speed steel on which we had trusted to Germany before August 1914, though there were abundant supplies of tungsten [1] within the Empire. Ought we to retain these industries on a manufacturing scale by national encouragement, or fling the pioneers, who during the crisis created them, back again on their own resources—tell them to swim as best they

[1] A metal of high specific gravity, which, in the form of tungsten powder or ferro-tungsten, is used largely as an alloy with steel in making cutting tools that keep their hardness at high temperatures.

may, or sink? I think there can be only one answer from any reasoning person: we are bound to sustain and fortify these key industries in view of future wars. It would be insane to let them go.

If we knew that the age of wars had passed for ever, the question would be a purely commercial one, a tariff matter. Then there would be plenty of good and bad argument on both sides. But there is not the least reason to suppose that the age of wars has passed for ever. Quite on the contrary, the spirit of nationality is perhaps stronger to-day than it has ever been during the history of man, and in the pride and ardour of nationality the seeds of war ripen. The question then of these key munition-of-war industries is not primarily a commercial one. It is a question of national security in the event of another great war in which we may be threatened by swift destruction if we have failed to learn the tremendous lesson of 1914–18.

I may be told that, if there is another world war, it will be fought in a wholly different manner from the last one, and that the weapons will in nowise be the weapons of 1914-18: that it will be fought with bombs and poison gases infinitely more deadly than any used so far, and that great nations, indeed the whole of human civilisation, will be swiftly, utterly destroyed. I do not believe these predictions: they are too easy and wild. They may be well meant, but I think they are ill founded. We shall be very foolish if we suffer them to militate against reasonable munition precautions. Another world war cannot, of course, occur in the near future, Europe being militarily exhausted, and in the main disarmed (the "campaigns" between Bolsheviks and

Poles, etc., are not worth serious consideration in this matter). So that to-day we are faced by the dangers of great industrial ferments and revolutions rather than by such events as that of 1914-18. Yet in the course of decades or generations we may be faced again by huge conflict among the Great Powers.

CHAPTER X

RICHBOROUGH: AND THE TRANSPORT OF MUNITIONS

(By WALTER SHAW SPARROW)

A CERTAIN amount of rubbish has been uttered about Richborough, that snug little port in Kent, where a great many useful and necessary things were done after our large ports and harbours began to suffer from phlebitis, a disease by which all war communications are likely to be clogged. When we pass from propaganda phrases about Richborough to sets of varied facts, we turn from humbug to a noble enterprise carried out at great speed almost without a hitch. As a rule, improvisation has to be nourished by a river of gold, a Pactolus. What chance can it have of being useful if its promoters are afraid to be spendthrifts? To grow trees to make our own ladder is foolish enough in a four years' war as in a brief life; but to try to do it "cheap," in order to please strait-laced economists, would invite disaster. So I cannot believe that no money was ever ill-spent at Richborough; but, on the other hand, I do believe that as a whole the enormous amount of work there was done with ample thrift. It merited the judgment passed on it in September 1918, by three noted experts appointed by the Select Committee on National Expenditure. These experts were Sir

R. Elliott Cooper, Sir Maurice Fitzmaurice, and Mr. Basil Mott, very distinguished members of the Institution of Civil Engineers. In their report they said : "As a war undertaking the services rendered at Richborough are of great national value ; there has been no undue extravagance, no waste of public money, and the maintenance charges are justified, in view of the functions performed." For once, then, we are cheek by jowl with true war economy.

Very entertaining is the way in which little Richborough was hustled into full public notice from its humble obscurity near Sandwich. In pre-war times no genius, military, naval, or political, had given a moment's thought to this lowly Kentish sea-nook as a harbour for cross-Channel war services. Its large bed of shingle, very useful for building purposes, had been discovered by Lord Cowdray's firm, who built a wharf at Richborough, and used the shingle in the Dover Harbour Works ; but shingle is not enough to give fame to a seaport, and other good natural things in the little place and the Stour valley were unnoticed till the need of relief ports—let us call them understudy ports—became harassing to our High Authorities. Even then Deal and Ramsgate were considered before Richborough was chosen for obvious reasons.

At a time when German airplanes were active night after night along our south-eastern coast, the fog that collected after sunset around Richborough was a natural guard against air raids and naval skirmishing. Deal was too open, too exposed, while Richborough, in its pleasant valley, had a sheltered port very little affected by gales of wind and storm tides. Its wharf could be enlarged, and there was abundant

space for new stores and workshops. Access to Richborough by rail was convenient; there was no existing traffic to be dislocated by hurried enterprise; and for cross-Channel work the nearness to French ports was an advantage plain for all folk to see.

As it is our national whim to pass over obvious needs till we find ourselves in serious danger, let us see how at last the natural good points in Richborough's port and neighbourhood were noticed and employed. This story is roundabout. It begins far off from Richborough in the Inland Water Transport Section of the Royal Engineers, an invaluable thing with a long name which was formed in December 1914. Its main business was to take over traffic and transport on the canals and waterways of Belgium and Northern France; to take them over and to develop them. Its administration at the War Office was placed under the Directorate of Movements, and at the end of 1914 a Deputy-Director of Inland Water Transport was put in charge of the British work in France. This work developed so rapidly that in October 1915 it became worthy of an overseas Directorate, and one was constituted. Side by side with this prospering enterprise in France was a swift improvement of the I.W.T. in our own country. Later, in September 1916, a new department at the War Office—the Directorate General of Military Railways, or Movements and Railways—enrolled the I.W.T. among its duties of control, appointing a branch department to govern inland water transport wherever our troops were active, and also to supply workers and materials for equipping and using docks both in and outside the British Isles.

Inland water transport could not act without

barges, barges at once and by the score. Could they be found? Thanks to that Gilbertian humour with which as a nation we seasoned our pre-war politics for the amusement of our descendants, our canal traffic, once so active and so picturesque, had been manœuvred out of vogue by ideal railway companies who declined to be harassed by deliquescent rivals at their board meetings. With a rare good sense full of consideration for the commonweal, it was seen that prospering canals, which circulated essential things at a cheap rate, while delighting all landscape painters, might cause railway shareholders to dream of liquidation, a nightmare in ways and means. But financial good sense, far-seeing enough to be philanthropic to shareholders in one great venture, may be pitiless war to shareholders in another; and thus when our war leaders cried out for barges, genuine British barges, fit for work on French canals, they were told that in this matter, as in many and many another, "the shortage was grave." As we had to make machines with which to make other machines, with which at last munitions of war were turned out, so at various places in our country barges had to be built, and men of full fighting vigour had to be employed for this purpose. As soon as the barges were built they were towed to Dover, where they were fitted out with stores, crews, and other requisites. Then across the Channel they went, and our Allies compared them with their own canal craft.

Little by little this routine of work became inconvenient. The tonnage problem, as it was called, became a nuisance in all our ports, and from a nuisance it developed into a national peril. At French ports also the congestion was described in official words

as "acute." The useful and necessary thing, then, was to bring as much relief as possible to this phlebitis. Could cargoes be shipped in barges from England through the French canals to inland depots, without being handled at French ports? The idea in this question was made real and very useful; out of it came a very fine cross-Channel barge service of stores, materials, and war munitions, by which our troops in the field were helped in the promptest possible manner, while much time and labour were saved at overthronged ports where our deep-sea tonnage required all hands.

But this great service needed a harbour of its own. Early in 1916 Dover had become unsuitable for it, partly because the service had grown too big for an important naval base, and partly because there were tidal difficulties at Dover which at times made the entrance difficult and even dangerous for barges and similar craft. For a time a store was opened at Ashford for heavy material, but the act of bringing the material by rail from Ashford to Dover proved troublesome, unbusinesslike; and as from day to day the overseas demand for barge service became more varied and more intricate, a new base for the I.W.T. operations was admitted to be imperatively essential. Then overworked officials, with the patience of Cabot or Vasco da Gama, set themselves to explore our bombed coast line, weighing the claims of Deal, measuring the aspirations of Ramsgate, and so forth; till they reached the conviction in March 1916 that Richborough was the best little port to be transformed and enriched.

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Two schemes were prepared in detail for the work to be done. Scheme A proposed the building of a

new wharf, with railway access and other admirable things, while the other, trying to creep up the Treasury sleeve, wanted to extend the existing wharf, the one built by Lord Cowdray. It seemed to blend economy with adventure, thrift with improvisation; it was a compromise, in fact. Mr. Lloyd George gave his approval to Scheme A, and when the Cabinet confirmed his approval, independent experts were called in to pass judgment on the Cabinet. To audit auditors may be more useful than I suppose it to be; but, in any case, the independent experts, Messrs. Rendall, Palmer, and Tritton, Consulting Engineers, had no fault at all to find with the Cabinet's judgment and decision. They regarded the scheme as well conceived, the design as sound, the estimate of cost as enough for good workmanship. Since our soldiers' lives had to be protected, King Jerry was to have no home at all at Richborough, not even a shooting-box in the Stour valley.

In June 1916 work on the new wharf was begun, and in six months, so rapid was the progress, a regular cross-Channel service began to settle into its excellent routine. At an earlier date than December 1916 a portion of the new wharf had been employed with success. Great credit, then, must be given here to the whole working staff and its officers. Brigadier-General A. J. Allen Williams was in charge, and responsible for the carrying out of all work in the port and depot; and later for the efficient use of the Cross-Channel Barge Service and the Train Ferry. His officers were as follows:

Chief Assistant, Lieut.-Col. C. L. Kempton.
In Command of Construction, Lieut.-Col. J. R. Robinson.

Chief Mechanical Engineer, Col. R. Holmes.
Traffic Superintendent, Lieut.-Col. W. Blomefield.
Chief Storekeeper, Lieut.-Col. J. A. Hawkes.
Marine Superintendent, Lieut.-Col. J. A. Carruthers, afterwards Lieut.-Col. W. Sayers.

It was in June 1916, or thereabouts, that the I.W.T. in France, growing wonderfully, needed a new suit of facilities for one-half of its work, shipping stores overseas, considered apart from the cross-Channel barge service. So new building enterprise was put in hand. Later, after the Directorate of the I.W.T. undertook the working of French docks and of river traffic in Mesopotamia, accommodation for stores had to be greatly extended, and barge-building also kept Richborough increasingly active. River craft for Mesopotamia required a design fit for one purpose, and barges for French rivers and canals had to be strong enough for varying weather in the Channel. Existing shipyards, already thronged with Admiralty and mercantile affairs, could not cope with this pressing need for small craft; and for this reason the barge-building yard at Richborough was of great national utility, not only easing the strain on other yards, but saving expense also in several ways. For instance, when barges were built on the north and north-east coast, they had to be towed to Dover or to Richborough, a risky and a costly use of invaluable time.

Plates, angles, and other necessary things were obtained from places not engaged in shipbuilding, were brought to Richborough and erected in the yard there together with building-slips, new railway extensions, new workshops, and an air-compressor installation.

In 1919 twenty-three building-slips were available, and surely they should be as useful for peace trading as they were for the enterprise of war. Further, an electric station was installed with power enough to supply the wharf cranes, and to light the works, camps, and other places also.

No sooner were the constructive undertakings begun than the regimental depot was removed from Longmoor to Richborough. At first it was decided to build a camp for a thousand men, but afterwards three thousand men could be taken and camped with comfort. In this way Richborough became the I.W.T. Depot, and received, trained, equipped, and governed all men belonging to this Directorate in the various theatres of war. Camps were built of light concrete work; a permanent hospital grew up almost as rapidly as Jack's beanstalk; and other buildings also, offices, canteens, institutes, aided the circulation of the four B's: 'baccy, Bradburys, barges, and battle materials. Within twelve months the completed work included the wharves, shipyards, stores, power plant, foundry, workshops, block yard, some eighty miles of railway track, and improvements in the river Stour. A new cut was excavated, and extensive dredging operations were pushed through with fine vigour. Though as a nation we like to be too late, we do work prodigiously when at last we set our minds and hands to immense jobs.

The whole of the Richborough work was done by official labour thoroughly supervised. There was difficulty in getting enough skilled tradesmen, so unskilled and half-skilled men were recruited, then trained in schools by experienced officers and N.C.O.'s. The schools at Richborough were very successful.

A continuous demand for good men came from overseas, and good men at Richborough were always prepared to go. In all more than 400 officers and 12,500 men were sent overseas, while 13,000 men, with about 450 officers, were transferred from Richborough to works of national importance in our own country. This uncommon success — "a top-hole achievement," it has been called—had its origin in the fact that the Richborough training, in the schools, as in the shops and wharves and barge-building yard, was thoroughly fitted for the jobs which it had to do well and swiftly. It was precept in practice, not precept in preaching.

But, of course, Richborough itself was not always at ease, since its workers were frequently changed. To train drafts and at regular intervals to send them away as skilled men was to strengthen Richborough through one period, and then suddenly to curtail the output of work while another draft was learning to be efficient. This flow and ebb were particularly active in the barge-building yard, where a large number of men were trained, because many were needed elsewhere for shipbuilding.

Cross-Channel traffic went on briskly side by side with the other varied business, the barges circulating a huge export both of war material and of other supplies. In 1918, for example, the exports reached a maximum of a hundred and twenty thousand tons per month. Four thousand tons a day in a month of thirty days! Consider what this means in human energy and in money's worth. Barges, then, going in their steady routine to and fro between Richborough and France, made another harbour than those to which they went—the permanent harbour of our history,

where they lie forever with our Navy, and our fishing fleets, and those intrepid merchant vessels that sailed out among submarines as though U-boats were not more dangerous to a ship than sharks.

In 1917 it became clear that the cross-Channel barge service, though in its own way excellent and satisfying, needed a companion service, almost free from old-fashioned history. Barges have a long pedigree, a rich lineage; they help to make the distant near and the past present; while a train ferry, despite the old history summed up in the word "ferry," a beautiful word, seems to belong almost entirely to our own times. A Train Ferry Scheme for Richborough, not fully completed till some months after the Armistice, in 1919, was approved by the War Cabinet in January 1917. It was a scheme full of rational ambition; it recalls to memory a story told by Oliver Wendell Holmes. A young married couple refused to plant fruit trees because they were certain that they would not live long enough to eat the fruit; so grandfather planted the trees, watched them grow up, gathered their first fruit, and devoured some of it. To start on a new vast scheme at Richborough in January 1917 seemed ridiculous to the over-young in faith, who believed the war would end long before the Train Ferry Scheme could be made at all useful. Vessels expressly designed had to be made; and proper terminal facilities also, with lifting-bridges at Richborough, Southampton, Dieppe, Calais, and Dunkirk. At Richborough, too, the entrance channel had to be deepened and strengthened by dredger. All this work went smoothly and well; so well, indeed, that in 1918 the export train ferry traffic reached a maximum of seven thousand tons a

week, and the import traffic three thousand five hundred tons.

But we cannot fully appreciate all these facts unless we call up before our minds truthful pictures of what the Allied position became between the spring of 1917 and May of the next year. Richborough was ministering to definite needs, and these needs took a differing urgency from the ups and downs through which the Allied cause wobbled.

Admiral Sims has published a faithful picture of our position in the spring of 1917. He arrived in London in April, at the time when the U.S.A. entered the war. Propaganda had hoaxed him; then our Admiralty placed before him facts and figures, and at once the difference between talking about truth and telling the truth was evident. "These documents," says Admiral Sims, "disclosed the astounding fact that Germany was winning the war, and winning it at a rate that, in four or five months, meant the unconditional surrender of the British Empire. . . . To say that I was surprised by this disclosure is expressing it mildly. I was fairly astounded; in my wildest moments I had never imagined anything so terrible. I expressed my consternation to Admiral Jellicoe, who said that Germany would win unless her submarines could be mastered and mastered soon."

Tonnage losses for several months proved that the total sinkings, British and neutral, had reached 536,000 tons in February, 603,000 tons in March, and that those of the current month, April 1917, would be close to 900,000 tons.

Among the facts made known to Admiral Sims was another of a startling sort: that the stories in circulation about many sinkings of German sub-

marines were fudge. "Since the beginning of the war only fifty-four German submarines, it was positively known, had been sunk, and Admiral Jellicoe told me that German shipyards were now turning out new submarines at the rate of three a week." Apply these matters to Richborough. At once it becomes plain that the value of cross-Channel services by barges and small craft was increased by each week's losses of deep-sea vessels. To develop these services was an imperious duty, no matter what the cost might be; hence the Train Ferry Scheme was a bright feather in the War Cabinet's cap.

Next year, after March 21, the increasing value of Richborough was intensified once again by another set of tragical events. German submarines had been put under control, but German Armies were advancing with vast power, and, as Mr. Lloyd George said in his famous speech at Leeds (December 7, 1918), our Mercantile Marine had to be withdrawn from our essential industries in order to bring over American troops by the hundred thousand. "We said, 'This is the time for taking risks.' We ran risks with our food, risks with essential raw material. We said, 'The thing to do is to get these men across at all hazard.' America sent 1,900,000 men across, and out of this number 1,100,000 were carried by the British Mercantile Marine."

There was reason enough then for every one at Richborough to be proud of his work, and thankful also that neither over-confidence nor a jostle of rival criticisms had prevented the Train Ferry Scheme from being carried out with the utmost speed and thoroughness. Our forces in France could be supplied, no matter how many big boats passed to and fro

as troopships across the Atlantic. Fault-finding is always busy, and some persons were always opposed to the choice of Richborough, though it was plainly the best place for the Train Ferry as well as for the barge service. Already it possessed facilities for the swift and efficient doing of new work: railway access was there, it required only connections and sidings; labour force and equipment were on the ground; the whole area was under an efficient military control well fitted to conduct the new service; and to build the ferry terminal at any bigger port on the same coast would have increased the congested state both of the railway lines running to the port and of the shipping traffic there. At a naval port, moreover, such as Dover, the Train Ferry would have been thrown too much in the shade by urgent naval needs. It could not have been a specialist as it was at Richborough.

What is a train ferry, and what are its advantages? To all intents and purposes it is an ordinary steamer, but it has no holds for the carrying of cargo, and the stern is cut down to within twelve feet of the waterline. At this level on deck railway lines or tracks are laid, and a train, with its locomotive and rolling stock, is run on board and carried direct from British to French railways, then taken at once by rail to places where it is wanted. A train ferry, then, may be called a sort of moving railway station that steams across water from one railway line to another, saving a double transhipment of goods and much time and expense in loading and unloading cargoes. As in great wars months should be valued as years, and weeks as months, and days as weeks, the Richborough train ferries, though employed late, soon paid their

way by avoiding a frequent handling of goods, by a swift circulation of essential things from shore to shore, and also by freeing our larger ports from much congested business. Also it is clear that, although the great Richborough scheme was conceived and carried out as a war enterprise, it should be as useful to us in peace, as train ferries were in pre-war times both on the Continent and in America.

In January 1919 the *Illustrated London News* reproduced an old print illustrating a design for a large raft-ferry planned by the French when Napoleon was teaching militarism to Prussia and to other victims. This proposed raft-ferry is among the early predecessors of the train ferry-boat. In 1869 a train ferry-boat of 220 ft., with a breadth over the paddle-box of 60 ft., and a displacement of 1600 tons, sailed to and fro on Lake Constance between Romanshorn on one side and Friedrichshafen on the other, carrying trains from bank to bank, and propelled by 200 h.p. The boat was made of iron; her horse-power was divided between two paddle-wheels, and each wheel was driven by a pair of oscillating engines which were independent. From 1872, in Denmark, much progress was made in the use of ferry-boats to carry trains between the mainland and the islands, and also between Denmark and Sweden. One steamer, the *Lille Boelt*, was built by Richardson of Newcastle, and her service from Fredericia to Strib was only two miles. She was not so long as the boat on Lake Constance, being only 139 feet, but although her tonnage was only 306, her i.h.p. was 280. On board she had only a single railway track. In 1910 the Danish Government had eight ferries for railway cars, and other vessels for mercantile traffic. Twenty-

two boats, with a tonnage of about 16,000, were employed in the passenger service alone, all the year through, so they were strengthened for ice-breaking. I collect these facts from the *Encyclopædia Britannica*. Four Danish ice-breakers in the train ferry lines were from 497 to 553 tons gross, with from 600 to 800 i.h.p. One ferry, connecting Gjedser with Warnemünde, went 48 miles across the lower part of the Baltic; but Germany introduced a longer service than this in conjunction with the Swedish Government. It was a direct ferry-boat line from Trelleborg to Sassnitz, a distance of 65 miles. For this service the *Dröttning-Victoria* was built by Messrs Swan, Hunter, Wigham Richardson, & Co. Dimensions: length 370 ft. over all, 350 ft. between perpendiculars, breadth extreme 53 ft. 6 in., 3050 tons gross, displacement 4270 tons dead-weight capacity, 600 tons at a draught of 16 ft. 6 in., 5400 i.h.p., and speed 16½ knots. Trains were shipped at the stern, and at sea they were protected from the weather, as the ship's bow was built in the usual seaworthy manner. This vessel could be driven through ice. She had ballast tanks, and powerful centrifugal pumps were fitted, so that the vessel's trim could be adjusted as necessary when trains were embarked and disembarked. On two rail tracks she could carry either eighteen goods waggons or ten full-sized passenger- or sleeping-carriages.

On board the Richborough boats there are four lines of rails, the two outer ones being turn-outs from the two main centre tracks which give direct connection with the shore. The ferry-boats have sides carried upward well above the trains, and consequently, when they are seen broadside on, they

resemble ordinary steamers, apart from their funnels, which are somewhat unusual. Students of these matters will do well to read the *Engineer* for January 10 and 17, 1919. They will find two articles well illustrated both with photographs and with drawings.

For the rest, the ferry fleet at Richborough had three twin-screw vessels, called T.F.1, T.F.2, and T.F.3. 1 and 2 were built by Armstrong Whitworth, who in pre-war days, in 1895 and 1896, constructed two very interesting ferry-boats, one for use on the River Volga and the second for service on Lake Baikal in Siberia, to carry trains across the lake for the Siberian railway. T.F.3 came from the Fairfield yard. At first the Richborough vessels were unsuitable for motor transport, but as soon as they were decked over, any motor vehicle could run aboard on its own wheels. They travel at a speed of about twelve knots, and their principal dimensions are as follows:

Length over all	363 ft. 6 in.
Breadth over fenders	61 ft. 6 in.
Depth moulded	17 ft.
Draught, loaded, forward . . .	9 ft.
Draught, loaded, aft	10 ft.

The carrying capacity of each vessel is 54 British standard gauge 10-ton railway waggons on their own wheels, or the equivalent in other stock, such as motor lorries and cars on one boat, tanks, guns, and cranes on their own wheels. In 1919 the fleet was reinforced by a Canadian train ferry-steamer, the *Leonard*, for which a second berth was provided at Southampton.

During the Armistice, and afterwards, Richborough continued to work at high pressure, as traffic flowed

back from France in ever-increasing quantity. As many as 200 lorries were brought over daily from France, for example, often rusty after rough wear and tear, like the homecoming locomotives. Most of the War Department material returned by way of Richborough, and from Richborough the A.S.C. supplies for the Armies of Occupation were exported. Also a barge service to the Rhine was opened.

It is worth noting, too, that demobilisation at Richborough was the most rapid of any unit in the Army. The depot excepted, all formations were "demobbed" during January and February 1919, and protests were made by the Eastern Command to the War Office that the steps taken at Richborough were too drastic. Later, too, there were outcries from another quarter. Unemployment in East Kent gave much anxiety, and as it was caused mainly by discharges at Richborough, the Ramsgate Employment Committee resolved to urge the Government to undertake the reclamation of Pegwell Bay and the making of a big harbour at Richborough. This twofold scheme, it was argued, besides increasing the Kentish farm-land, would be of great help to our export business with the Continent. Pegwell Bay could be reclaimed as land is in Holland.

As regards the depot at Richborough, it was reduced to a skeleton establishment, big enough to do justice to the Transport Service men who returned to be demobilised from various war theatres. Also in August and September 1919 recruiting of I.W.T. men for Mesopotamia became active again. A draft of 170 was sent overseas in mid-September. If this work is transferred to one of our permanent military depots, the depot at Richborough will still

need an embarkation staff and various troops till Richborough ceases to be a W.D. port.

Again, the storage accommodation is another thing of great use and value. It has been employed through 1919 for sorting and rehauling the plant and material arriving from France, and preparing them to be forwarded to their destinations. This work, very useful and necessary, has not interfered with the trade interests of any industry.

One camp at Richborough was handed over to the Eastern Command for the storage of ordnance supplies: and another passed to the Post Office to be used for the sorting and salvaging of R.E. signal material. In a third camp valuable plant and perishable stores were collected on behalf of the Ministry of Munitions, and kept there for disposal. In fact, the whole of Richborough became a War Department store, and if Richborough had not existed, material would either have been sold at a knock-out price and lost to the country, or other ports and stores would have been far more congested than they were, with the result that commercial transport would have been hindered ever more and more.

Last of all, it is interesting to note that useful work for the common good was done at Richborough during the 1919 railway strike. Barge services were run not only from Richborough to Calais and Antwerp, but also between other ports; between Deptford and French ports, for instance, and between Poole and Deptford, with A.S.C. supplies. As for the train ferries, they were used exclusively to carry motor transport, each of them making one trip a day, with an average load of fifty vehicles. Whenever it was

possible other lorriés were brought over in barges; and within an hour or so of their arrival at Richborough the vehicles were on their way to Grove Park and to other M.T. depots. Richborough, then, did a great deal to help in the distribution of food.

"I will first know what I may do for safety," says Joseph Hall, "and then I will try what I can do for speed." Between 1914 and 1919 safety and speed in our imperious affairs had to drive tandem, so to speak, and at Richborough and elsewhere speed was between the shafts the main motive power, while safety led in a restive, irregular manner. But the main result recalls to memory some great words which are attributed to King Alfred the Great:

"This I will now truly say, that as long as I have lived, I have striven to live worthily, and after my life to leave to the men that come after me a remembering of me in good works."

CHAPTER XI

LABOUR

After all the theories as to how we ought to fight and where we ought to strike home at the Central Powers had been elaborated, the hard fact remained that the war was in the main one of attrition and exhaustion. Germany yielded not until we were able to weaken her sufficiently in regard to material and food through the blockade, and to dishearten and overwhelm her Armies by superior man-power and a stupendous bulk of munitions. Whether we might have won in 1916 or 1917 through cleverer strategy, or unity in design and command, is for history to say. Personally, I have not the smallest faith in any of the theories as to how the war could have been won years before it was. I am convinced there is nothing much in such theories but misplaced ingenuity. Possibly Germany missed one or two early opportunities in 1914 of winning, or at least of "drawing" against the Allies, such as the phase just before the Battle of the Marne, or a little later in her rush for the Channel Ports, and her failure against inferior numbers weakly armed at the first Battle of Ypres; but there is nothing to persuade one that the Allies in those days, or even in 1916 or 1917, missed signal opportunities

in the West or East of crushing Germany by some brilliant strategic plan.

The bed-rock truth throughout the struggle was that Germany had by far the most powerful military machine the world had ever seen. There was no way to victory save that of wearing it down by a long succession of sledge-hammer strokes. Those strokes could only be dealt effectually when shells, guns, and all the accessories of war were delivered to our forces, as well as to those of our Allies, in immense bulk; and it was not until Germany was altogether out-munitioned by the British effort that the strokes became irresistible and the enemy's machine was broken.

The chief credit for this effort, whether we ascribe its motive to patriotism or to pay, must be set to British labour—to the millions of manual workers, men and women, by whose exertions in factories throughout the kingdom the goods were made and delivered.

There was exaggeration in praise and in blame over the workers' effort all through the war. But this truth is irresistible: *The workers made the munitions by which our Armies were finally able to destroy the colossal military machine of Germany.*

The workers by no means deserve the entire credit for the munitions feat. The resources and organising wit of the great and lesser directors of industry and the skill of the men of science and inventors played a great part. But the gross bulk stands to the credit of the working classes; that is clear as the sun, where a great deal of the motive may be vague and cryptic.

. . . . . .

Difficulties with labour in the earlier part of the war were very grave. There were difficulties in the early part of 1915 through the hindrance of munition work by drink. Resurveying that question to-day one can perceive—what one did not necessarily perceive at the time—that Mr. Lloyd George was right in the protest he made in the spring of 1915 against drink. He seems to have overstated his case; he may have meant in zeal to overstate it; and had total prohibition been forced on the working classes the effect might have been disastrous. But the result of his action was good; the State got a grip of the drink traffic during the rest of the war, and the danger of excessive alcohol through high wages and physical overstrain was averted. Some of those who misdoubted the speech he made on the Defence of the Realm (Amendment—Number 3) Bill, April 15, 1915, can now read it in another light. I confess I was one of those. Alcohol had to be limited and its strength reduced—the thing was interfering with the supply of munitions.

That was a lesser and passing difficulty with labour. Far graver were trade union restrictions on output. These restrictions and demarcations had retarded the supply of munitions during the first six months of war, and, when the demand of the Army for more shells and guns became urgent early in 1915, the Government met the trade unions and tried to remove the ban.

The first important step was the Treasury Conference on March 17-19, 1915, when the Chancellor of the Exchequer and the President of the Board of Trade met representatives of great trade unions, who agreed to put aside the practices for the period of the

war. On paper the bar to production seemed to be removed; but in fact the arrangement did little more than draw attention to the difficulty. The conference was merely the first of a long series of discussions, appeals, Acts of Parliament and statutes under the Defence of the Realm, and commissions which were addressed to the settlement of labour disputes in 1915, 1916, and even 1917. The difficulty was ultimately surmounted for the period of the war. That is proved by the huge and increasing figures of output; these being far more convincing than any scraps of paper, parliamentary and other. But the removal of the restrictive precautions of organised labour was a long and very touchy negotiation, and there were disappointments and reactions long after a settlement appeared secure. Not all the disputes between the three sides—labour, capital, and Government—referred to this matter. Wages and hours of labour caused the more sensational and alarming quarrels and occasional stoppages in various munition and allied industries; for example, the South Wales coal strike in the summer of 1915, and the Coventry strike at a later date. But there were an immense number of differences and agitations over the restrictive practices. Were we to compile an exact labour diary of the whole war we should discover that dilution, which removed the most important of the written restrictions on output, was disputed again and again long after it appeared to have been completely settled. There was throughout the war a large body of opinion in the organised labour world which, despite the Government pledge to restore the rules against dilution, etc., after hostilities had ceased, was fearful of parting with its rights. During the war

there was, naturally and rightly, an outcry against the restrictive practices; an indignant public demanded that they should be abandoned. But there was also a great deal of intemperate and ignorant censure of labour generally for valuing these rights, notably indulged in by comfortable lookers-on whose forte was neither fighting nor munition-making but grumbling from the armchair.

Restrictive rules of trade unions were deplorable during the early part of the war, and they are an evil at any time. Their restoration at the close of the war is an evil.[1] But it was, and is, ignorance or mischievous partisanship to set the blame for this evil wholly on the labour organisations. Had the Ministry of Munitions or the Government taken that absurd attitude the result would have been the failure of Great Britain in the war. Happily the authorities knew better, and addressed themselves to the matter in a wholly different temper. So did fair and far-seeing men in the world of capital. Labour was not alone to blame for the restrictions on production. The condition into which our industrial system had been drifting for many years before 1914, the unemployment terror, and the state of civil war between the two sides in industry—we must saddle these with the blame for what occurred soon after war began.

Indiscriminate censure of labour for the strikes during the war, and for the long succession of disputes and difficult negotiations over the restrictive practices, is foolish and unpatriotic; it aggravates the industrial ill; it plays into the hands of foreign competitors

[1] Used against the demobilised soldiers they are disgraceful.

who wish to oust British enterprise from the world's markets.

For what reason were the trade unions restricting output by written and unwritten rules before the war and in its earlier stages? Many people have passionately condemned the workers without coolly examining or understanding the question. They seem to suppose the workers kept down output just for the devilry of the thing. They are wrong. The restrictions were due to two causes. First, the workers had found in certain cases that if they produced—before the war—abundantly, the rate of remuneration for piece-work tended to drop; that there was an inclination among some employers to regard a man producing an exceptional output as one who was making too much money. So the rate of remuneration would fall. Secondly, the men believed that exceptional output by some led to others being flung out of employment. Rightly or wrongly they believed and believe it. Their belief was that the unstinted labour of the stronger must lead to the semi-starvation and misery of the weaker. Now, even people with private means, who are secure from actual want, often do not relish unemployment. It may not be a scourge to them, yet it may be an indignity and vexation. But unemployment among workers who depend week by week on their wages is a horrible, haunting terror; particularly to those on whose exertions the security and decent comfort of wives and children depend. Only dissolute or unintelligent workmen are without the intense dislike or dread of unemployment. The workers' belief as to output may be entirely wrong, but it is not a dishonourable one.

The restrictive practices, which the Government had, before the Treasury Conference, appointed a Committee on Production (with Sir George Askwith, Chairman) to report on, consisted, roughly, of five: (1) Demarcation; (2) Female Labour; (3) Regulation of Boy Labour; (4) Overtime; (5) Entrance to a Trade. These restricted output by (*a*) limits placed on effort (this was direct restriction), and (*b*) by limits placed on the numbers who might be employed (indirect restriction).

These practices, written and unwritten, were viewed by the trade unions as the weapons of defence and offence forged during a long period of combative years; and, considering the subject dispassionately, it is easy to understand the importance which organised labour attached to them. When the representatives of the unions agreed at the Treasury Conference to abandon the restrictive practices for the duration of the war, they were in advance of the opinion of great numbers of their followers. The conditions of the pact were incorporated in the schedule of the first of the Munitions of War Acts, but in practice it was found necessary for a long period afterwards to settle the disputes and allay the suspicions of the workers by dilution commissioners, etc.

The term dilution signified the introduction of women and semi-skilled and unskilled male labourers into work which, by the union rules, had hitherto been reserved for skilled hands, and for men only. It must be admitted that, until recently, there have existed equally rigid and prohibitive rules among organised professional classes against women and unskilled or unqualified persons entering on their preserves. Women as doctors and women as barristers

were not tolerated by the medical and legal professions a few years ago; and jealousy in this has not wholly disappeared. Doctors and barristers might reply that the objection to women and unqualified persons intruding in their professions was simply due to the fact that they were unfitted for the work. That, however, is very much the reply the trade unions might have made when the question was raised in 1915. Certainly it has turned out that a vast amount of work in the engineering shops and in the shipyards and elsewhere which was regarded before the war as fit for skilled hands only could be done as well by the unskilled of both sexes after a short training. But that is one of the discoveries of the war. It surprised not the workers alone. Many directors of industry and men of science were astonished by the results of women' labour in various munition fields. A great man of science has told me that, when it was proposed to set unskilled women to work in making optical instruments of exquisite precision, he did not believe it could be done with success. He was amazed by the result of the experiment.

The question of demarcation was also a delicate one. Introducing a skilled worker in one branch of industry into a different branch was against the customs of the trade unions, and it was no easy matter to persuade labour to allow this. The Clyde, Tyne, and Tees workers consented to the suspension of the custom, but not till after much negotiation. Until it could be effected there was no securing mobility of labour—shifting a skilled worker in one branch of industry to another branch where, for munition purposes, he was more urgently needed.

To ride roughshod over labour susceptibilities in these questions of dilution, demarcation, etc., on the strength of the Munitions of War Act, was out of the question. They had to be nicely adjusted by frequent negotiation, especially in the earlier stages. It was essential that the representatives of labour should collaborate with the State. Accordingly the Ministry of Munitions was aided by a committee of labour leaders, the National Advisory Committee on Output, which sprang out of the Treasury Conference in March. Its duties were to settle such matters, and also to prevent strikes and disputes. The Committee was aided by local labour advisory bodies, each consisting of seven members elected by those trade unions that were concerned with munitions. Though the dilution of labour, even in the final stages of the war, was not absolute throughout the country, and in many factories the presence of women or unskilled workers in certain departments was resented, great progress was made in 1916 with this reform. Thus, between January and April 1916 the Dilution Commissioners in the Clydeside area had to hold a thousand conferences; whereas in two months of the summer they held only forty, ten of which were in the second month and only two in the final fortnight. It then became practicable for employers to introduce dilution schemes by agreement with their workers, without calling in the commissioners.

The effects of diluting skilled labour with quickly trained women and unskilled men and boys were illuminating. There were even cases where absolutely new and unskilled hands did better work in producing munitions than trained hands. A comparison was made late in the war between the munition work of

these quickly trained women of Great Britain and the professional work of some of the best United States firms. It showed that in the production of shells, and in fuses and other repetition tasks, the women's machine work here was as good as, and sometimes better than, the United States standard. As we have seen, women with a three months' training or less turned out parts of fuses, magnetos, optical instruments, and all kinds of work hitherto restricted to highly skilled men. I saw them in numberless factories, large and small, in the industrial districts handling gauges and managing gun and ammunition lathes as if they had been bred to the work. One heard the same report almost everywhere in North or South—that even during their short training courses they were able to increase substantially the output of munitions. There was little scrap and waste of material in many of the training schools.

The best account of the work of women dilutees in the factories which I have read is Miss L. K. Yates's *The Woman's Part: A Record of Munition Work* (Hodder & Stoughton, 1918). It traces the progress of women through the schools and instructional factories into the shell, fuse, cartridge, small-arms ammunition, optical-instrument, and aeroplane shops; shows them at work in the shipyards, in the laboratories. I saw them in all these, and other kinds of munition factories, during the last year or so of the war, and I do not believe she exaggerates the value of the work these hundreds of thousands of dilutees carried through. Zeal, good humour, and discipline prevailed, so far as I could discover through observation and enquiry, in the women's departments of the factories.

The phenomenon was not peculiar to this country. I was impressed by it in France early in 1917 at, I think, Renault's factory near Paris. It was a feature of the Italian munition campaign, too; and it would be foolish to question whether Germany lacked the ardour and efficiency of women in the same extraordinary movement. The thing probably was world-wide, so far as fighting nations were concerned. It was a revelation in the possibilities of unskilled labour, but equally at least a revelation in sex. This is one of the features of the war that never has been exaggerated, though constant propaganda, almost a synonym for exaggeration, played round it.

Early in the war, when skilled men in engineering work were being recruited for the Army, factory employers began to turn their attention to what Miss Yates describes as the untapped reservoir of labour in woman's work; and "the adaptation of a larger proportion of machines to a 'fool-proof' standard certainly eased the situation, yet the problem remained of the immediate provision of workers able to undertake advanced as well as simple work in engineering shops." But at first it was difficult to develop large training schemes in the shops, because, for one thing, these needed all the material they could secure for actual output of munitions. So local institutions and education bodies, some of them allied to the Universities, began to use their technical schools for training recruits. The London County Council was a leader in the movement, instructing unskilled men, at first in simpler engineering work. By August 1915 a group connected with Mrs. Fawcett's National Union of Women's Suffrage Societies financed a scheme for training women to become oxy-acetylene

welders. One saw women carrying on this process all over the North in 1918. These training efforts were sporadic and struggling in the early stages, but by the autumn of 1915 the Ministry of Munitions co-ordinated the movement, and established a training section. By October it had the power to finance approved schemes throughout the kingdom, and about fifty colleges and schools, hitherto acting independently, were brought into touch with the Ministry. Payment of maintenance during instruction was adopted, and soon recruits were passing from the simpler processes to such work as tool-setting, lead-burning, and gauge-making. At first men only were eligible as students in the higher classes. Women were restricted to lessons in drilling, boring, planing, snipping, and working to size.

The last of these tasks was especially important: "the chief battle of the training centre with regard to the instruction of women was . . . the implanting of a feeling of exactitude in persons accustomed to measure ribbons or lace within a margin of a quarter of a yard or so, or to prepare food by a guess-work mixture of ingredients." Exactitude is a stiff lesson to learn in a six or eight weeks' training course. Yet the experiment throve, so that by the close of 1917 we had more than forty training schools for engineering work and nine instructional factories, in which two women to one man were being coached. The instructional factory commonly absorbed and trained the more promising recruits in the schools, but often the schools, too, taught gauge-making and tool-setting.

In August 1916, women were working on some 500 munition processes; during the last year of war they

were engaged on almost every factory, foundry, and laboratory operation for which they possessed enough physical stamina. It was laid down in 1917 by the Ministry of Munitions that, by March 31, 80 per cent of the workers engaged on new and continuation contracts for all sorts of shells up to 4·5″ must be women. That shows the progress made. In some factories women had to undertake every process in the making of a shell, even from the forging of the billets in the foundry.

Among the institutions receiving students, once the movement was in full swing, were, in the London district: the Battersea Polytechnic, Brixton L.C.C. School of Building, East Ham Technical College, Erith Technical School, Shoreditch Technical Institute, Wimbledon Technical Institute and School of Art. Birmingham had five schools. Bath, Bradford, Colchester, Derby, Grimsby, Liverpool, Leeds, Lancaster, Plymouth, Portsmouth, Oldham, Newcastle, Nottingham, Darlington, Sheffield, Tunbridge Wells, Walsall, Oldham, Peterborough, Reading, Salford, Wednesbury, York, Wellingborough, and other towns, were in the movement. The keen advocates of industrial education often lament British backwardness in this study, contrasting the conditions here with those in Germany. There is a good deal of truth in what they say; but technology certainly became a cult throughout Great Britain between 1915 and 1919. The study—like other branches of education—is rather repellent to many people; but it was a big factor and a boon in the war. Too little has been talked and written about the way diluted labour was organised and put through its paces in the industrial campaign during those tremendous years.

A vague idea prevailed that the unskilled men and women were collected by national appeals and advertisements, plunged more or less helter-skelter into the factories, where at once they started to pile up shells, fuses—and fortunes. But that would only have resulted in chaos. The vast majority had to undergo a training, though of a lightning order. They were trained in 144 hours, or less, *i.e.* six weeks, six days a week, four hours a day, and that was the maximum.

The author of the brochure quoted above gives an animated sketch of a scene in a fuse-shop as a result of this training in school or instructional factory. The time fuse is the most complicated part of a shell, with its needle, stirrup, pellet, ferrule, and other toy-like components passed from table to table to their final place of assemblage. A hundred and fifty gauges are needed for the correct measurement of one type of fuse; seventeen gauges pry into the percussion end alone of one fuse body, "one ten-thousandth part of an inch being the limitation of variation allowed." Sometimes one heard complaints, when shell-making started on a prodigious manufacturing scale, that the gauge difficulty was a scare—that what we really needed was more tolerance than Woolwich and other authorities were inclined to countenance. There may here and there have been reason in the complaint, yet extreme accuracy in gauging was a fault on the safe side. As the barrage system developed, absolute accuracy in the timing became, for the sake of our attacking forces, more and more essential; and this could only be secured by minute and infallible measurement in the munition factory.

The explanation of this triumph of lightning-trained labour in munition work lay partly in the enthusiasm which the women brought to their new occupation; but no zeal or energy could have availed without an exact division of labour. Therein lay a grand secret of success. Division of labour, the advantage of the single purpose, in industry was not a new discovery during the war. It was an old story—some people even tracing it back to the inspiration of Plato! Perronet made in 1760 some minute observations in France as to the advantages of pin-making. He calculated the advantage of wire-drawing, pointing, twisting, and cutting the heads, by a series of distinct operations each undertaken by separate gangs of workers. He showed that if division of labour were not adopted the pins would take longer to make and their cost would be between three and four times as large. In the nineteenth century an English writer, Charles Babbage, pressed for the division of labour on the ground that it needed less time for learning and resulted in less scrapping of material. Moreover, through division of labour, less time was spent in shifting from one occupation in the factory to another, and in adjusting the more delicate tools used in different branches. Also, Babbage pointed out that a higher degree of skill was acquired through frequent repetition of the same task, and that this was likely to suggest the contrivance of tools and machinery to execute the various distinct processes.

With so many advantages in the method there are probably a few disadvantages also. I should think, from what I have seen of the repetitive processes in the munition factories, that monotony—the dull level of

ceaseless grinding monotony—may be a disadvantage in the long run. It is a question whether Babbage was right in perceiving an educator in this sameness and simpleness. It may tend not to stimulate ingenuity, in the worker at any rate, but rather the reverse. Tens and hundreds of thousands of the new hands who did their own engineering task admirably were not much nearer being true engineers at the end of their term of exemplary service in the shell and gun shops, etc., than when they started work. They had necessarily become fixed in a groove and came to work therein like an automatic or semi-automatic machine. Monotony is one of the ills of the industrial worker's life. It tends to sour and deaden the worker. Yet the advantages of a minute subdivision of labour, far more general than it had ever been with us before the war, outweighed any disadvantages. We could not have won through without subdivision of labour and standardisation. Dilution and subdivision of labour increased and quickened up our output prodigiously. As I mentioned in an earlier chapter, we were able by this reorganisation of labour, linked with the new inventions and devices of science, to produce more articles, and better ones in many instances, at a lesser cost in money, time, and manual effort. When the country settles down to steady industrial work we shall apply this lesson of war to peace production. It will give the workers a more generous share of leisure than they knew before the war.

What on the whole was the temper, the attitude, of the workers during the struggle? On April 25, 1918, the Minister of Munitions pointed out that, as for disputes and strikes during the autumn and

winter of 1917–18, these were provoking, but, in view of the volume of output, practically negligible. "Less than one-fourth, and latterly less than one-sixth, of 1 per cent of the total time worked has been lost" through these causes.[1]

There followed after March 21, 1918, the "acid test" of the British munition movement. The German offensive swept back our armies and captured an immense mass of our guns and ammunition. We had to make good or go down. We could not make good entirely by the reserve stocks. The workers were called on for an extraordinary effort. What happened was this:

If we take the production of heavy guns at the figure 100 before the German thrust, it stands at 172 in the five weeks following March 21; very heavy howitzers at 218; heavy ammunition at 213; machine-guns at 132; small-arms ammunition at 142;[2] hand grenades at 166.

So we made good. The situation was saved. It was not to the credit of labour alone, but labour subjected to the strain of three and a half years of monotonous work must be allowed a good share of the thanks. Moreover, as to that one-fourth of 1 per cent of time which had been flung away on disputes and strikes, it must be remembered that the men and women in between fifteen and sixteen hundred firms, wherever required and requested, gave up the Easter holiday, and worked hard instead on munitions.

[1] According to other figures on this subject only one-fourth of 1 per cent was lost for the twelve months of the fourth year of the war; whilst during April 1918, an exceptionally good month, only one-fiftieth of 1 per cent was lost, or what would amount to one day in about thirteen and a half years.

[2] See some remarks on Kynochs' factory in Chapter IV. "The Armament Firms," page 84.

"Let us have an end of the carping and croaking which goes on about the attitude of labour towards the war!" exclaimed Mr. Churchill. He was dwelling on the events of the autumn and winter of 1917–18, and the rally over the German offensive, and was exulting over the fact that the lost munitions had been replaced. Previous episodes were not at the moment in discussion. Nor did he foresee the discreditable Coventry strike which was to follow. However, constantly viewing and reviewing the temper and attitude of labour from August 4, 1914, to November 11, 1918, I reach this opinion: his words would apply well enough to the labour effort as a whole during the war.

There were selfish and passionate outbreaks from time to time. There was heavy drinking in 1915. There were sullen periods and patches, not only on Clydeside, but through the industrial districts during later parts of the war. There was a Revolutionary cult in 1917 and 1918. Not that the cult was peculiar to the working class. Zeal for Revolution—for Revolution at least in Russia—was, for a few weeks, exhibited in Pall Mall, Whitehall, and Westminster; and it did not completely die out until the wrong sort of Revolutionists came on the scene. Historians of these years will scarcely express wonder that, when the ruling classes threw themselves into the cause of a social and economic Revolution abroad, the masses should have played with the idea of applying it at home.

When, however, we have resurveyed all these disaffections, and gone even into the thousands of tribunal prosecutions against individuals under the Munitions of War Acts, the broad fact emerges that

labour's effort in the war was impressive and magnificent. There has been nothing resembling it in the history of England. THE GOODS WERE DELIVERED.

Give science, give organising and administrative efficiency at headquarters and locally, give the captains and lieutenants of British industry, all reasonable credit for this feat; even so, that vast mass of material built up during the war is far from fully accounted for. Candour must insist that, first, it was the workers. It will be regarded by the historian of our day as labour's monument.

The feat has been illustrated by all sorts of figures which look like fable, but are fact. As one Minister succeeded another, he was able always to tell the same story whether the war went well or ill: home-made munitions of every variety always on the increase, so that the bombardment and barrage of one record artillery battle was dwarfed in a few months by its successor; and this though (1) skilled hands in the chemical and metal factories were constantly being drawn out of industry, put into the fighting forces, and replaced by hastily trained substitutes; and (2) though the increase in the numbers of munition makers did not increase in anything approaching the increase in output.

The following table gives an idea of the difference between the scale of production a few months after the Ministry of Munitions had begun to organise in earnest and its scale near the end of the struggle. But shells, guns, gun carriages, machine-guns, rifles, and small-arms ammunition, though the most essential of munitions, the bed-rock material for battle, were only a portion of the war output, and that table is an account of the growth in those arms alone.

Growth of Output, 1915–1918

	3rd quarter 1915.	3rd quarter 1918.
Shells—		
18-pdr.	1,703,000	8,800,000
4·5″	205,000	2,280,000
60-pdr.	112,000	1,320,000
6″	28,000	2,820,000
(?) Heavy	35,000	560,000
Expenditure in France (average weekly)	2,300 tons	48,600 tons Highest expenditure in a week, 83,100 tons; week ending 29·9·1918.
H.E. and Propellants—		
H.E.	10,470 tons	43,691 tons
Propellants	3,309 „	15,816 „
Guns—		
Light	903	1,949
Medium	196	437
Heavy	21	557
Very Heavy	20	121
Gun Carriages—		
Light	883	1,267
Medium	196	428
Heavy	21	356
Very Heavy	20	89
Machine-Guns	1,719	33,507
Rifles	176,239	287,755
Small-Arms Ammunition	368,500,000	746,000,000

The following table is instructive as showing the rate of increase in the output of four forms of gun and howitzer shells in 1916 and 1917:

	18-pounder.	Field Howitzer, 4·5 in.	Medium Guns and Howitzers.	Howitzers above 6 in.
Weekly to June 30,	1	..	..	..
1915	..	1	1	1
Between July 1, 1915, and June 30, 1916 .	6½	8	7½	22
Week ending June 30, 1916	17½	27	34½	94
Average weekly Feb. 1917	28	52	71	423

The fact about the figures of the last item is that, to start with, we had only from four to five hundred guns, virtually no heavy howitzers—and therefore we did not produce their ammunition.

. . . . . .

Figures of output such as these, the critic may object, do not prove any special goodwill or patriotism in the workers. Those who suspected the labouring classes during the war may attribute the huge output of munitions to the fact that most of our peace industries were stopped, or slowed down, and the men, to earn a livelihood, had to produce munitions. There is something in this, but it does not go well with the assertion that the workers were poisoned by pacifism or bolshevism, for pronounced pacifists and bolshevists would not be in the mood year after year to produce material of war on a great scale, and of an excellent quality.

Figures which show that no year of the war was so prolific in new ships at Clydeside as 1913 are formidable. If the workers of Clydeside were doing their duty, how was it they failed to produce ships during the peril of the submarine campaign so

abundantly as in 1913 ? Do not the figures of 1917 and 1918 point to ill-will ? Those figures certainly are disagreeable. But, in considering them, we must not forget that great numbers of the strongest and most vigorous men in the shipyards of 1913 were after August 1914 drawn into the fighting forces. Much of the best of the youth of Clydeside and other shipbuilding districts was drained by the war. That told on output. Nor let us overlook the fact that, though merchant ships fell below the 1913 record, ships of war were being built on a mighty scale. The public heard little of this secret till the Armistice, when the truth was released ; we should have had a greater output of the merchant ships during the war had we not been forced to concentrate also on the Royal Navy.

There is another charge made against labour. Its unfriendly critics say : "Yes, the workers produced munitions, but they could only be induced to do so by incessant bribery. The wages and bonuses were continually rising higher and higher at their threats. They would have 'downed' tools and stopped the war, if the Government had not invariably yielded to their outrageous demands."

The wages were high contrasted with those of 1913, and there was a continuous rise. But it is absurd to leave out of reckoning the rise in the cost of living, in the price of the ordinary necessaries of the worker's life. After the difficulty in the supply and allocation of food was settled, the average munition worker, male and female, was, incontestably, better off than before the war : and, had thrift been a characteristic of the masses of the workers, they would have put by substantial savings out of their war wages and bonuses.

In some instances—even allowing for the price of necessaries of life being 100 per cent higher, and even much more—men made astonishingly high wages for work which was not very hard or skilled. Yet the rise in the pay of the *average* hand was not exorbitant considering the nature of his work, the continuous strain, the monotony of it. There was a romance, a glamour, about munition making, "a wonder and a wild desire" about it, that was felt by many a novitiate. Women fresh to the thing were stimulated by this in their repetition work. It touched those members of the cultivated classes who threw themselves into the movement, and strove with the ordinary factory hands. From a spectacular point of view the work was often wonderful, even beautiful. But the horny-handed professional workpeople employed in the munition arsenals and the yards for eight, nine, ten, twelve, fourteen hours [1] a day, week after week, month after month, could not be expected to see the thing in this fascinating light. They turned into human machines—and machines have no sense of romance.

[1] One hundred hours a week, for considerable stretches of time, was by no means an unknown record. For extraordinary spurts of effort I refer the reader to some remarks on labour in Chapter III. "Woolwich."

CHAPTER XII

THE FERMENT IN THE FACTORIES

We often heard the lament in 1915 and later that the masses of the munition workers knew little of the war, and did not grasp its mighty issues or the peril to themselves of a triumphant Germany. Better propaganda in the industrial districts was recommended as the way to bring truth home to the workers and prevent disputes and strikes. I thought this myself formerly; but after seeing more of those districts I recognised that no propaganda would cure the ill. It would only have deepened the suspicion in the North, that is all. Besides, the idea soon spread among the masses that the struggle, whatever its result, would open up to them a new world, social and economic. They became absorbed in this idea. I believe it stirred them more deeply than the daily news from the Front, except during sensational events such as the opening of the 1918 German offensive. It set the North in a ferment, and eclipsed the interest taken in the war. In the course of a tour through those seething industrial districts, one could hardly fail to note certain strong labour tendencies in 1917–1918, some of which may be touched on under the following heads.

Labour and Control in Industry.—Before the final

passages of the war it was no longer possible to regard the labour ferment in the North and Midlands as simply one of wages and hours of work. A more ambitious demand was noticeable. A mass of the workers had begun to claim that labour should have (1) a share in the control, and (2) a share in the profits. The feeling in regard to control was far stronger than supposed. Many people till lately had scarcely heard of it. Even trained inquirers and experts sometimes overlooked it. I was discussing the labour position in Glasgow with a friend who devoted attention to figures and statistics of Clydeside during the war. He scarcely mentioned control.

He said, "Things were going on smoothly until the Churchill bonus was sprung on us—that was the root of most of the mischief to-day. Now they are all, piece-workers and time-workers alike, insisting on the bonus—there is no end to it."

He took a very dark view of the outlook; but the bonus and the wage questions chiefly oppressed him. My strong impression is that the effect of that bonus has been altogether exaggerated. Had it never been thought of, much less given, the unrest in the North would have been quite as great. The bonus had nothing to do with control; and the strong demand for a share in that among the munition workers was largely at the root of the ferment.

What does a share in the control or management of industry exactly mean? So far as I could gather, the workers and their leaders mean by it (1) a hand in the ordinary daily working and direction of the concern, (2) a hand in the financial arrangements and decisions, (3) a hand in the commercial programme and decisions. The three together cover the ground

of control and management. There was a good deal of diffidence among the men whether they were yet competent to engage in the financial side. It needs a knowledge of business, of company law, of such tricky things as preferred and deferred and cumulative shares and debentures, which few possess. What could a working man, a works committee, a shop stewards' committee know about charges of, say, watering capital? Then, as to the third branch of control, how many workers in any industrial concern feel themselves competent to tackle and advise on contracts?

What was the attitude of Russian industrial workers towards the question of control after the Revolution started in the spring of 1917? The effect of that Revolution on the workers in the North I have touched on—it was portentous. It has all through been hard to get good information about anything Russian, especially about industrial and economic matters. The price of geese, or the potato ration, has been the kind of fact served out to us—with the purely personal side. That has always been the way with revolutions. Even the historians of the French Revolution have filled their pages with the dresses, phrases, and intrigues of the starred performers, the mimes of the melodrama. I believe that (March–May 1917) the Russian industrial workers asked the employers for a part in the control of the concern as regards housing the workers, wages, and other things affecting the ordinary running of the business—a sort of welfare control, *Rabotchie Komitet* (*i.e.* Workmen's Council). Some months later they pressed for a part in the full control, including finance, commercial arrangements and decisions—*Kontrolnie Komitet* (*i.e.*

Control Committee). Commonly the latter, if not the former, was refused. I heard of one instance in which neither was refused, though the employer was not a Russian. He granted the first at once, only bargaining with the men that they should take the whole of this welfare side off his hands. As to the second, he fully explained to the men the practical difficulties they would have, being inexpert, and tried to dissuade them. They still desired it; and he gave in. How the second would have worked in practice no one can tell; for, soon after, business in Russia collapsed through the progress of the Revolution.

As to the employers who refused, their staffs going out on strike against the Revolution, they were swept away. The Soviets came in. The industrial concerns were nationalised, but their production in most cases must have been virtually *nil.* It is a question whether in the early stages of the upheaval a general accommodation between employers and employed—as well as an accommodation between the bureaucracy, the banks, etc., and the revolutionary leaders—might have saved the country. As it was, the bureaucracy seems to have retired before the Bolsheviks came on the scene, and whilst the "Russian Girondists" were still in power. But it is safer to conclude that the Revolution, once started, had to run its course; and that an accommodation, to avail, should have been made well before the event. At any rate the death—or long hibernation— of industry in Russia affords food for reflection, both to employers and employed, in this country.

As to the movement over this question in the North, I heard complaints on both sides about various

disciplinary rules, such as the hooter, time-keeping, smoking during work ; and discussions as to whether the workers should or should not "run" this side themselves. There was irritation and often a sense of humiliation among the workers on such points. They said they were reduced to machines, to mere "hands." Yet not all works committees would quite relish disciplinary duty ; and, moreover, they would regard it as a quite subsidiary side in the control of industry. However, I am sure shared control is coming.

Labour and Parliament

It is often asked, "Why should labour think of working out its plans by unrest and strikes, seeing that it now has in its hands the means to dominate Parliament and to pass any measures of reconstruction it pleases ?" The weapon in the hands of labour, *i.e.* the new franchise, is so trenchant that most of us find ourselves asking that question. Clearly it is in labour's power, if labour chooses, to conscribe wealth by means of a Budget ; or it can, equally, by Acts of Parliament, revise or reverse the whole position in industry. The House of Commons is still supreme, and labour has merely, by its overwhelming majority of votes under the new franchise, to put itself in parliamentary power and at once introduce and carry all the legislation it desires. Why, therefore, resort to strikes and threats of strikes and unrest generally to achieve what can be done so much more thoroughly, and so much less wastefully, through the vote ?

That has been in fact the line taken by most of the parliamentary representatives of labour ; they have

wished to reconstruct through the vote. Their line corresponds to the line of those Irish Nationalists who deprecated the excesses of the land and Home Rule agitations in Ireland, and proposed to act by parliamentary pressure; except that the task of labour in Parliament appears far easier than that of Irish Nationalism, for labour should be able to dominate in numbers in the House of Commons, whereas Nationalist Ireland could only secure some eighty-six seats, and for the rest had to rely on the support of English and Scottish outsiders whom she could not completely trust.

Nevertheless all over the country there is a great number of working men, in mines, factories, and shipyards, who distrust the parliamentary method; and this attitude was observable through the war. A scene in the election at North Loamshire in George Eliot's noble story, *Felix Holt, the Radical*, is to the point. A trades-union speaker has just been addressing the electors on behalf of Harold Transome, the Radical candidate, and telling them of the great things which can be done by the franchise. But when he has ended, and gone away to repeat the speech elsewhere, Felix, who is a sort of world-Radical, instead of a party one, gets up, and says:

> In my opinion that was a true word spoken by your friend when he said the great question was how to give every man a man's share in life. . . . I want the working man to have power. I'm a working man myself, and I don't want to be anything else, but I think he expects voting to do more towards it than I do.

He goes on to tell his hearers how they can get more power sooner without votes. Certainly Felix

Holt's programme is not much like that of the mass of trades-union and other workers in this country to-day. Rather, it resembles something by Ruskin. But the distrust in the almighty power of the vote which Felix felt is felt by the workers to-day—by the non-parliamentary wing of them. Perhaps they begin to distrust their own leaders directly those leaders accept office or even take an important, responsible position in the House of Commons; it is conceivable. Or they may have unconsciously absorbed a good deal of the general censure of the day as to whips and wire-pullers being able to manipulate the vote in Parliament; that, again, is conceivable, very. Any-how, the average working "hand" in the chief centres of industrial ferment cannot visualise a solid body of three hundred and fifty labour M.P.'s trooping into the Aye lobby on the third reading of a Bill, say, to conscribe the wealth of the country, or to nationalise the land, mines, shipping and other essential industries; or even a Bill which would give him a part in the working and the profits of the factories and work-shops, etc., in which he is employed.

The parliamentary business is too far from his ken to be implicitly trusted. He does not understand the "feat and mystery" of its dignified procedure. Parliament is composed, to his eyes, largely of the great ones of the earth: captains of industry, millionaires, labour leaders whom those great ones combine to extol. What relation to his daily life in the pit shaft, by the blast furnace, or at the cogging-mill, can a three-line whip or a full-dress debate have?

In a workshop at Motherwell I mentioned to one of the workers that a great man in Parliament had

come out of that shop. I supposed the workers were very proud of him, as he of them?

"Oh, he's well enough," said the worker—there was nothing about him to complain of. It struck me as not ill-natured. It was not "teaching the rest to sneer," but there was a "damning with faint praise" suggestion about it. I think it will be found that "He's well enough" is a familiar attitude toward the leaders who have climbed high at Westminster. There is a great deal of human nature in it.

In future elections labour, having had full time to organise—and the question of the war being no longer the vital one—will return a larger party to Parliament than it has there to-day. If it secures the great majority of the returned soldiers' votes it may nearly sweep the board; for there is not the slightest doubt that by then the working women will throw in their lot with the working men. But it does not follow at all that the Clydeside and Tyneside shipwrights, engineers, caulkers, and riveters, or that the South Wales and Durham miners, will conclude, "Now we can get all we want by Parliament"; still less does it follow that they will, on the strength of this excellent parliamentary prospect, resolve to cease meanwhile from what we style, by a euphemism, "unrest." I am certain from what I have seen of the munition and other workers in the North and elsewhere during the war that they will not. Always bear this in mind: the workers secured during the war benefits not through Parliament; they secured them through outside pressure and demonstration. And they know it.

What is said above does not imply that I belittle the power which the new franchise has conferred on

labour. Personally, I believe it is so great that no ingenuity of wire-pullers—let these be more gnostic even than Mr. Johnson and Mr. Jermyn in *Felix Holt, the Radical*—can ultimately avail against it; and I believe that methods of unrest meanwhile may weaken the cause of the workers by irritating or alienating the general public. Felix Holt may have been dreamy, an idyllist—George Eliot, like Kingsley, was given to that type of worker—still there was bullion stuff in what he told the North Loamshire workers: "I'll tell you what's the greatest power under heaven . . . public opinion, the ruling belief in society about what is right and what is wrong, and what is honourable and what is shameful." Will public opinion support workers who, with the franchise in their hands, yet resort to cruder methods in their impatience? The great industrial North should carefully consider this question. To put it no higher, it is a practical one.

What will the demobilised Army do? This is still an exceedingly interesting—and obscure—question. The fighting forces from France and elsewhere, having gradually dropped back into civilian positions, and rejoined their pre-war colleagues at home, may profoundly if imperceptibly affect the position in regard to reconstruction. In the North I noticed during the war that there was a good deal of subdued discussion among workers in this matter. There was a movement—though I could not trace that it came to much—by some of the civilian workers to press for a higher scale of pay for soldiers and sailors. I daresay the movement, so far as it went, was quite a genuine one, and that shipwrights, engineers, and other hard workers at the base, in calling for higher

minimum wages and bonuses for themselves, felt sympathetically that soldiers and sailors at the Front ought equally to be remembered. But it is not disparaging to note that the workers at the Base might also feel that to take any other line would be to antagonise their associates at the Front. This attitude was observable before the last autumn of the war. For instance, in the spring of 1918 there was a remarkable meeting of workers, Clydeside shipbuilders and engineers at Shandon, and the question as to what line the soldiers might take, on their return from the Front, was touched on there. It was suggested that the mingling of classes at the Front and the good understanding often reached in the trenches between the working classes and the employing or capitalist classes might affect the attitude of returning soldiers towards the old labour and capital struggle at home. Shared perils and hardships at the Front for years might have tended to bring the private soldier (*i.e.* ordinarily, the working man at home) and his leader (*i.e.* ordinarily, a member of the capitalist or employing class at home) into closer sympathy with each other than formerly. This was touched on at the Shandon gathering; and the topic was often ventilated when labour gathered at home and discussed its future.

Yet there was and is a great deal of doubt as to what the demobilised Army wants in the matter of reconstruction, and what it means to do. Neither labour here, nor capital, knows for certain. There is little out of which a sure opinion can be formed. The last General Election proves virtually nothing as to the attitude of the fighting forces in France and elsewhere. They did not go into the matter then.

The soldier from the Front is the dark horse of the election races that will by and by be run; and, equally, it is obscure what line he may finally take in the labour ferment and unrest which exists in the North to-day and in a less pronounced form throughout populous industrial England. It is safe to assume, I think, that he will go in as a rule with labour. In fact, what is he but labour—whether or not you insist that he is labour's aristocracy? This seems to tell in favour of his joining in the ambitions of that great mass of workers in the North, which is "out" for a share in the profits and control of industry.

On the other hand, he has learnt the value and necessity of discipline; he has recognised that, without it, he would not have "won through" in France and elsewhere; and there is that sense of sympathy and intimacy which the hardship and danger of war have engendered at the Front between poor and rich, class and mass. The pull therein is obviously the other way. Besides, the fighting men undoubtedly were angry over disputes and strikes during the war.

Finally, there was during the war, in some cases, a lurking suspicion, in others a generous admission, among workers at the Base that the fighting forces on their return must be regarded as the pick of the people; that the soldiers and sailors could, if they chose, lay claim to premier honours in the work of having saved the country. Their womenkind, it was felt, would in any case claim this for them. And their voice in the future schemes of reconstruction would therefore be more commanding. The attitude of the average wife, mother, sister, sweetheart, of the returned fighting man from the Front was in fact

that of Mrs. Loveday in *The Trumpet-Major*—whose author knows working-class psychology as no other English novelist save George Eliot has known it:

> "Well, if you must go, you must," said the miller with emotion, "but I think it somewhat hard that, of my two sons, neither one of 'em can be got to stay and help me in my business as I get old."
>
> "Don't trouble and vex about it," said Mrs. Loveday soothingly. "They are both instruments in the hands of Providence, chosen to chastise that Corsican ogre, and do what they can for the country in these trying years."
>
> "That's just the shape of it, Mrs. Loveday," said Bob.
>
> "And he'll come back soon," she continued, turning to Anne. "And then he'll tell us all he has seen, and the glory that he's won, and how he has helped to sweep that scourge Buonaparty off the earth."

Substitute Kaiser for Buonaparty, by Mrs. Loveday understand Mrs. Thomas Atkins, and the passage gives a capital idea of the way the fighting soldiers' and sailors' wives and mothers regard and still regard the thing. The man who served years in the trenches must on the whole get the pull among the working-classes in the coming years. It will be a difficult thing to put him down and out in any future plans for the reconstruction of the country. But nobody knows exactly what he will do. The most reasonable view is that the demobilised soldier from the trenches will declare for labour with a strong reservation in favour of discipline. Many soldiers are strong and avowed Socialists. But Socialism, unless the term is grotesquely misapplied, does not indicate indiscipline and anarchy; on the contrary, Socialism connotes far too much discipline and galling interference by the State in our private affairs and liberty

to please most of us. "Man is born anarchical everywhere, the Socialists are trying to put him in chains," would not be a bad individualist rendering of Rousseau's saying.

Labour and the Higher Politics.—The flippant would term this the "Shakespeare and the Musical Glasses" side of labour in politics. It includes such questions as diplomacy; remaking the map of Europe; the future status of the natives in our African colonies old and new; democratisation of our government in India; and—coming nearer home, though not necessarily to a simpler problem—What of Ireland? Is it to be Federalism; or Dominion Home Rule; or pure self-determination for the Irish people?—and, if this last, is Ulster to be suffered to exempt herself out?

What has been the attitude of the great mass of the workers in mines, shipyards, factories, farms, towards these questions during the last five years? I think it has been one of indifference. How could it be otherwise? What opportunity has the man working ten hours a day on the plates or rivets of a ship to study Federalism *v.* Dominion Home Rule; or the rights and wrongs of the dispute between Greek and Bulgar and Slav over Macedonia; or the question whether the correct award of the Great Powers as to Dalmatia should be founded on geographical and strategical or ethnological grounds? Dalmatia and Macedonia are very important questions to Europe. Unless well settled, they may plunge us into a fresh war within a few years. But as not one leisured and educated man or woman in a thousand here has considered the Macedonian or Dalmatian difficulty, it is not to be expected that shipwrights,

miners, and factory hands working eight to ten hours a day should do so. The same applies to diplomacy; India; African natives; Federalism or Dominion Home Rule.

"Ask me another," the ship-caulker or the shop-steward may reply to a query on any of these heads.

And, after all, that would be somewhat the attitude of the London diner-out, or even of the average man "interested in politics." Such questions are—where no personal gossip can be extracted from them—Shakespeare and the Musical Glasses to the class as well as to the mass. "Bother Macedonia—they're always quarrelling there," and "Which is Dalmatia?" are observations one might hear in the Club or the Lobby.

Yet the labour leaders and the annual gatherings of the massed trade unions have always, once or twice a year, devoted resolutions and debates to such higher politics; and, now they are on the front Opposition bench, they will scarcely drop the custom. We shall hear indeed a great deal more than we have heard on these themes from the intelligenzia of labour. But I noticed during the war no sign of the mass of labour of the millions in the North and Midlands addressing themselves to high politics. They were simply out for the great social and economic changes: higher wages, easier hours, better conditions of labour, and, notably, a share in the profits and control of industry. Any one of these items bulks far larger to their view than the European, African, Indian, and Irish problems all together. There is not much Jellybyism among the workmen of Lancashire or Clydeside.

Taking a hand in the higher politics, playing a

part among the *οἱ χαρίεντες*, may improve the qualifications of the labour party in Parliament to form a Government. But it tends to divert activity from pure labour politics; a man who is dabbling in diplomacy and international ethics cannot be concentrating so effectively on those homespun questions of working hours and bread-and-butter. Many of the workers are aware of this; and, as part of the higher parliamentary business, they may be a little suspicious of it.

They tell themselves that they will achieve their economic programme quicker by rough unrest than by European statesmanship.

Labour's Contribution to the War.—Of old, England won her wars on the stricken field or on the water—and there was an end to claims as to the true procurers of victory. Only one other source of victory, "the playing-fields of Eton," is supposed to have been mentioned in a particular instance—Waterloo.

But between 1915 and midsummer 1918 various war winners, other than Army and Navy, were indicated. One statesman announced that the war must be won or lost in the wheatfields of Britain, another that it must be won or lost in the shipyards. A third claimed kitchens and store-room cupboards as the ultimate field of victory or defeat. All these claims were gravely asseverated: chapter, verse, and exact dates could be given. Incidentally, the war winner was he who put his thousands or millions at 5 per cent into War Bonds; the war loser he who kept those thousands or millions at 4 per cent or 6 per cent tied up in other securities. Besides, monstrous and impudent claims were set up that this

or that individual won the war, or would have won it in 1914 or 1915 if he had been given a chance.

But the great essential effort, the defeat of the Central Powers, was accomplished by the fighting at the military and naval Fronts and the munition-making at the Base. The one called for courage and suffering, the other for endurance in manual work. The second was the achievement largely of labour at the Base. It was far safer than the first: it was far better paid. Still the fact remains that, to win, the country had to trust the workers at the Base to produce and deliver in time huge quantities of guns, shells, tanks, mines, aeroplanes, ships. There were quarrels between employers and employed over management and wages; there were strikes, sometimes the fault of one side, sometimes of the other. There were differences between employers and the State, and employed and the State. However, the goods were delivered.

It might have been expected that labour would put this fact forward insistently in its claims for better conditions in future. The industrialists are not shy in such matters as a rule, and here seemed a fair opportunity. Claims for patriotic services during the war were not unfashionable at the Base. But, for some reason, labour and its spokesmen have all through been singularly reticent in this matter. I heard no worker in factory, workshop, shipyard declare that the war was being won there. Workers were not shy to press their claims on the ground of the high price of food, of long hours and monotonous work, of bad management in workshops, of the large profits of capitalists. All that ground was constantly travelled over. A man has talked to me for an hour

on these and other reasons why the nation should give labour an ampler share in the country. He has not mentioned labour's contribution to the war; and it has struck me that he was overlooking the trump-card in labour's hand. Was it that labour thought the reply might be, "Yes, but your munition effort at the Base was safe, compared with the soldiers' part in the trenches"? I hardly think so, for that applies to every effort at the Base. So far as I noticed, the patriotic claim was not pushed even in the election, and electioneers are not a shy race when capital can be made out of claims. I noticed that one labour leader in a speech observed that the workers had done their "bit," and that it was a pretty fair bit, in winning the war. But he did not pursue the subject. The omission is the more remarkable in that many of the workers were decidedly proud of their output in various branches. Men, discontented with their work in a shop, have, as I have mentioned elsewhere, asked to be put on to the tank-making job, for instance; they have said that in making tanks they felt they were doing good war work, unmistakable war work. The same has applied to ships; and, I have little doubt, to heavy guns also, and other munitions that struck on the imagination.

Whatever the reason, there was the fact: labour did not and does not base its demands for improved conditions on war-winning among other claims. It preferred to press on ground irrespective of the war-work accomplished. During the war it was often suggested, as I have said, that propaganda would be useful in disturbed areas to impress on men the urgent need of speeding up in order to defeat the enemy, etc. But experts were against it. They

advised that it would only make the restless more restless and suspicious. I believe they were right. The average worker in the North is rather suspicious. He would have wanted to know what was behind these incentives to patriotism. It would be interesting to learn whether this is an insular attitude or whether it applied also to munition workers among the Latin races—is a capital and labour phenomenon, generally.

Labour Pacifism.—I was unable to discover that this tendency existed to a large extent once the war was fairly joined and the munition areas in full blast all over the country. The vast majority of the workers meant to see the thing through. The fact that some of the leading spokesmen, parliamentary and other, of the workers talked undoubted pacifism was deceptive. They did not represent the views of the workers in regard to the war, though they did represent the workers in regard to the constant ferment over wages, hours, and various points of management. The election in 1918, if it showed anything about labour, showed there was very little pacifism. The new women-voters may have had much to do with turning out the most observed pacifists, the Aunt Sallies; but, after all, most of these women-voters in the constituencies concerned were themselves labour. The result, even if the women had not voted, would have been the same—the candidates would have gone down, though the figures against them would not have been so large. There certainly were during the war some pacifist agitations — for example, the agitation over the Stockholm Conference in the summer of 1917, but they passed.

Labour unrest from 1915 to 1919 was a totally different thing from pacifism, though commonly confused with it. Sometimes the workers who called for higher wages, or struck for higher wages, were termed profiteers; sometimes they have been termed pacifists. This indicates the confusion on the subject. We must stick to one thing or the other, we cannot have it both ways; for profiteering thrived on the war and wanted more of it, whereas pacifism wished to stop the war, profitable or not. Outside the ranks of labour many people—capitalists, tradesmen, adventurers—have been accused of profiteering, but I never heard any of these people arraigned for pacifism. One might as logically conclude the woman was pacifist who, on the strength of a good separation allowance, declared the war was too good to last.

At the back of the agitation during the war, evil German influence, even its money, was always being talked about. But really these instances were few. There were black sheep among the workers—there are to-day—and they are dangerous. I believe they are more dangerous to-day than during the war, for the Russian Revolution is fired by the spirit of world-wide propaganda, and economically and socially it is very perilous. The attitude of British statesmen, Conservatives equally with other parties, in 1917 was distinctly unfortunate. They accepted the Revolution. They were bound to do that, otherwise Russia would at once have gone out of the war instead of keeping a kind of end up. But unfortunately they accepted and believed in it as first and foremost a German manifestation (though really the German was a small side of the Revolution), and they cultivated

it with exceeding fervour. That advertised the Russian Revolution, even pushed it, among the great masses of workers in the North; and those workers seem to have instinctively perceived other motive forces besides the German influence—*i.e.* bread-hunger, land-hunger, and the old smouldering revolt against the entire Russian social system—behind the Revolution more clearly than our highly educated political opinion. That Revolution, directly it started in 1917 when almost everybody was praising it here, attracted the workers' notice. It made a grave impression in the North. I do not think that real Bolshevists were numerous there—the Héberts, Chaumettes, and Anacharsis Klootzes of the Russian Revolution. It is ridiculous to describe all strong Socialists as Bolshevists. The War Cabinet contained an advocate of Socialist doctrines, but to say the Cabinet was tinged with Bolshevism would be carrying the joke too far. Yet, though a great deal in the North that is loosely termed Bolshevism is no more than the strong Socialism perfectly familiar there years before Russia fell into revolution, it is impossible to doubt that there is a favouring soil for it among those masses in ferment. I spent many days wandering about the grey back streets and the slums of those northern districts, noting what was offered to the people to read and to drink, noting their general environment outside the yards and factories, and that was not a heartening experience on the whole. I count it a fortunate fact that during the war the wages were good, food—except for a while—was plentiful enough, and unemployment completely absent.

Labour and the Crown.—It is difficult to make

frank observations on this, for there is a disposition to look for snobbery or perfunctory commonplace; and not to supply it is even regarded as disloyal. But the masses in the industrial parts of England and Scotland saw so much of the Crown during the war that the subject is distinctly to the point. My impression is that the Monarchy made headway with the people in those anxious, tumultuous areas. Packed crowds, the flutter of bunting, and the bustle of local magnates do not necessarily prove kinship between the Crown and the masses. Curiosity to see the great does not prove it. But there was more than this to form a judgment on during the King's various visits to the great industrial districts, notably Clydeside. I happened to be several times in parties which have accompanied the King through yards and various industrial factories. I did not notice an ill-natured demonstration, trivial or marked, in one of them, but a great deal of lively interest and enthusiasm which could not possibly have been arranged for the occasion. Not the adroitest organisers could have provided the occasional outbursts of cheers which punctuated the King's second progress at Clydeside. There were various moving and convincing scenes during that and other tours in Scotland and England. I recall one especially, where, leaving the works, the King chanced to notice a young man in workman's clothes standing at attention in a line of much older men, soldiers past service. The King turned aside and went up to this man and asked why he was there. The man answered that he was an escaped prisoner from an enemy internment camp. This man gave his replies in the natural, self-possessed way which many others did, throughout

that and other similar tours of the Crown. It was "the man's the man for a' that and a' that" spirit of Robert Burns; and, well understood, it was the nobler homage. The King passed on after two or three minutes, and then after complete silence a storm of cheers and the laughter of sheer delight burst out.

There is no improvising that sort of thing. It springs from pure impulse. The munition girls made usually a louder demonstration than the men. They were not shy. They jostled and shouted for all they were worth; and in one instance, an *aide-de-camp* laughingly told a bevy of them to come on and get a nearer view; and on they did come!

One heard the use of such visits discussed. Do they lead to a larger output? Was it wise for the Crown to risk the appearance of intervention between the two wings of industry? And so on. Such fears and puny objections miss the fact that progress and pageantry were never needed more than to-day if kingship is to be known about, popular among masses of working people. And, if ever there was an effective progress or pageant, it was one of these occasions, set in the huge force and fire of workshops at full blast, crowded to the roof with the toilers. The spectacular side of kingship, as of other forms of leadership, appeals to every class. The cultivated mind requires spectacle and symbol, as it requires mystery and vision; and it would be a great mistake to imagine that people whose lives are spent on incessant physical toil, often in a very grey environment, were not in the same category. The Crown gained by every royal visit to the great munition-making districts; the thing was of substantial national value.

Labour and Education.—The great majority of the workers in the North and Midlands are not much concerned in the matter; they have not devoted thought to it. Their attitude towards education approximates to that of a large number of people in other classes. But there is a minority, keen, determined, sometimes indignant, which is increasingly concerned with education. There is no privilege which this minority is more anxious to obtain for the workers than higher education. It thinks that the workers ought to have such opportunities of education as will enable them to read, for instance, works on philosophy, history, natural science, political economy.

Now that every man and woman has the vote and we have adopted democracy out and out, education becomes absolutely essential; and the cultivation of the mind is far more important than it was under the old system. If cultivation of mind was not safe for the masses thirty or forty years ago, the absence of it is far more dangerous for the whole nation now. There is a deplorable dearth of mind-cultivation among these masses of workers in the North who turned out the munitions, despite the growing and almost passionate desire for it in the minority. The books I noticed in the shops where the workers get their reading matter were not good books. There was a certain amount of second- or third-class stuff there. The rest was not vicious, so far as I noticed, but it was rubbish. The graphic side was rubbish too. The first as much resembled literature, and the second art, as the slums in the North resemble noble architecture. I know nothing about the music offered to these masses, but the

drama served out to them, I believe, is not better than the books. In fact, all the marketable cultivation is largely compact of false sentiment and lurid melodrama. The organisers and spokesmen of the factory, mine, and shipbuilding industrialists have been pressing hard for more leisure for the men, for an eight- or six-hours day all round; and by scientific subdivision of labour and the ingenious improvement in machinery, we can produce more goods than formerly at the expenditure of less time and labour. That, as I have already said, is a great industrial discovery of the war. It applied to hundreds of essential munitions during the war. It can be applied to a far larger number in the near future. It is certain that there will be more leisure for the workers, despite the coming struggle between the rival commercial nations. Unfortunately there is no prospect at present of that leisure being turned to the uses which the minority of workers desire; for, with this market of rubbishy books, art, music, and drama so ready and profitable, how can an appetite for true cultivation be whetted? Education Bills alone will not do it—not in generations! To spend even a short time in the environment of the industrial North and Midlands is to realise that. Elementary education even raised to the scale of the schools on the next rung of the ladder will not do it. Why not try fresh experiments altogether if the promised leisure and relaxation for these millions of "hands," these "rude sons of toil," is to be set apart to any extent for true cultivation? The experiments might be carried out partly through the State, partly through individual and collective public spirit. I saw it stated that among the books ordered by the Govern-

ment for the troops at the Front were 30,000 copies of Shakespeare. Now, if troops at the Front could read Shakespeare, workers at the Base could have done so. They were of the same class; they had the same training, except for the rigours and discipline of war, which are not likely to quicken a man's appreciation of literature.

Passing through workshops of all descriptions in the industrial districts, talking to the men in the tool-making rooms, in the engineering and the pattern rooms, and in the technical schools, I was struck by the intelligence of workers. They could explain and reason about their machines and devices in a way that set one on thinking. There was a great deal of intelligence at work in these munition shops—and not only among those who claimed to be the highly skilled. It is a crude distinction that divides one of these workshops into (*a*) labour or physical effort, and (*b*) organising or brain power which directs it all. I think both sides, where both are fair and working well together, agree that such a sharp dividing line cannot be drawn.

Philip Gilbert Hamerton, in his work *The Intellectual Life*, devotes several chapters to "Aristocracy and Democracy." They are bright chapters on education. Hamerton held no brief for either aristocracy or democracy. He lashed both unsparingly where he thought them wrong, and he pointed out good qualities in both. French Communism and the spirit of revolution he hated with intense passion. He desired culture for the toiling masses, and pointed to this very form of intelligence which has so often struck me lately in the great workshops of the North. "A friend who had a strong constructive and experi-

mental turn told me that as a rule he found gentlemen less capable of entering into his ideas than common joiners and blacksmiths because these humble workmen, from their habit of dealing with matter, had acquired some experience of its nature." These men are often wonderfully sure and quick-witted in their knowledge of, and reasoning over, *things*, as Hamerton expressed it. Many men and women of this order of intelligence are quite capable of reading and enjoying Shakespeare, Burns, Johnson, Scott, George Eliot, Kingsley, and scores of other great English authors. If "the humanities" can be brought somehow to their notice, the coming hours of leisure will not be wasted on rubbish—or on liquor or betting—so much as they are to-day.

This question of true education is not to be confused with technical education. The minority of the munition workers were keenly interested in that too, and had interesting proposals to make. There is difference of opinion both among men and masters as to whether that education should be specialist or not, and as to how it should be controlled, but I do not gather that these amount to serious quarrels between the two sides in industry. Some of the best-equipped factories have lending libraries of technical and purely scientific books. The technical education problem is an important practical one. It affects output and efficiency. But *the* education question in the industrial world to-day is the higher one—the humanities. It is that which is stirring passion and enthusiasm among the brightest spirits in the industrial areas. There are men who are quite as ardent—and as fierce—about it as about the minimum wage, unemployment, share in management. It is

a flame among them, the fire on their altar. I would urge people not to take the line that all the education which the workers need is that which will make them more efficient at their trades, more capable of beating the foreigner in the production of goods, make them sharper fellows. Such a line embitters the intelligent and ambitious minority which is eager for refining influences. It would not antagonise them more if they were told that wages should be reduced and hours of labour increased.

. . . . . .

One word more on this theme—this somewhat savage, this very anxious, theme—of labour, and I have done. I admit I detest the crude extremists, the desperate spirits; and I dread what they may do. I am a Conservative, devoted to the twin causes of order and of continuous steady progress upwards and always upwards. But, though anxious about the fierce ferment in labour to-day, I still believe this country will by and by win through. I believe it chiefly through what I witnessed myself at the British Front in France during the war. The strength of our race, the best of our race, worked and fought there: and the vast bulk of it was simply British Labour. I believe that if this were put to the great man who commanded our Armies for three years there, and led them to victory at long last, he would heartily agree with it.

CHAPTER XIII

WELFARE

(By Walter Shaw Sparrow)

After 1914 welfare work became very vast and very energetic. To try to sum it up in a chapter would seem rather like trying to plant an oak sapling in a thimble. We can do no more than glance at it here and there, while connecting it with our national character.

For a hundred years and more we have been too easy-going as a people towards that mixed inheritance of good and bad which birth and society have given to boys and girls. If we wish to live in our history as welfarers, genuine citizens, we must note what varied things of to-day make the distant near and the past present; also we must regard the future as an unwritten drama with a plot and cast partly chosen by ourselves.

To-day, instead of being truthful to causes and effects, we wish as a nation to forget how steadily we helped the Prussians between 1864 and 1914, till at last we imposed on boys and young men the awful welfare duty of fighting against a world of odds. Among our casualties there were many scores of thousands who in pre-war days were too young either to vote at elections or to be angered by the wise

candour of Lord Roberts. As their welfaring was to save their country from perils invited by negligent fathers, they were martyrs as well as rescuers; and thus the nation owes them an atonement which should be paid in remedial contrition, in deep healing penitence.

At the head of our welfare workers, let us enshrine our glorious dead, and the not less glorious wounded. After them come the fighting men who passed through battles unhurt; and just below, all in line, we find our fishermen, with sailors of the mercantile marine; our surgeons and nurses, and the industrial fighters, women and men, girls and boys. Bereavement runs through all.

From this ample general view of welfaring, we pass to that industrial ordeal by which our country has long been oppressed; an ordeal in many respects resembling war. It collects a great many casualties and breaks far too much health; while dooming vast multitudes to monotonous toil. Its results in debilitated young men startled our recruiting officers. Welfare workers, then, should be thoroughly frank when they study industrialism. Most artisans are mere servants to machines, mere Gullivers in a Brobdingnag of marvellous mechanisms, which do skilled labour if Gulliver keeps them clean and fit for their swift movement. More and more we need machines and an ever-increasing output, though the monotony of attending machines has been, and is, and will ever be a root cause of industrial unrest, with strikes and sects of agitators.

Among these conditions pride of craft perishes. Where this pride is active, as among artists, men will bear hardships patiently; where it is absent, no

increase of wages will produce content, as humanity is ruled by gifts of the spirit, not by mechanical drudging. Handicraft has a soul, and machine-craft a body, vast and uneasy.

As a general return to handicraft is impossible, welfarers can do no more than humanise as much as possible the industrial stress and strain, remembering always that progress in the people's education will bring forth new problems by kindling ambition and revealing new causes for discontent. The spiritual nature of man will resent more and more a lifelong subordination to machinery; and hence the need of something to replace the lost pride of craft, a social cement perhaps impossible to replace adequately.

For these reasons all symptoms of industrial unrest should be watched and studied with a sympathetic alarm equal and similar to that which medical men bestow on great diseases, such as cancer and consumption. Only fools talk about fighting Labour to a finish, with help from "the blessed companionship of machine-guns in action." Machine-guns as a cure for the spiritual troubles provoked by machine drudgery is advocated now and then in swell clubs by old men in their second childhood, who should go about accompanied by keepers; but persons of good sense know that the useful and necessary thing is to seek for all causes of industrial fretfulness, which may easily become as autocratic as martial law. To gather these causes together, and then to keep at close quarters with them, is the main duty, that welfarers have to fulfil with tact, sympathy, and judgment. It is the great principle of order in their research and thinking. It helps them to map out for us what they learn and the relations of its separate

departments. It proves that there are causes of two sorts, the old and inherited, the new and fertile. Among the new is the disrepute into which statesmanship has fallen owing in part to its pre-war follies, and in part to its war-time blunders and weak deceptions.

As for the older causes of industrial unrest, the main one is that the poor have retentive memories, particularly after they have begun to rise to a better position. They carry their bad past along with them as soldiers do their scars and bitter memories. So welfarers ought to be close readers of our industrial history. Never should they say, "Why moan or weep over spilt milk?" In politics spilt milk is only another name for causes and effects; and history and experience prove that most politicians from age to age carry the political milk-cans with a similar carelessness. Such a book as Benjamin Disraeli's *Sybil*, which reveals the root causes of many social evils, will always be invaluable to welfare workers. Spencer Walpole also is an excellent author for any one who wants to know what our country was like when Socialism and Chartism emerged together from the horrors of early Victorian farming and industrial strife. In 1841 no fewer than 800,000 hand-loom weavers, almost displaced by machines, earned 2½d. a day. A shilling a week was a common wage in Manchester, Rochdale, and elsewhere. One-tenth of Manchester's population, one-seventh of Liverpool's lived overcrowded in fetid cellars and in other slums where decency and health were destroyed. Twenty women begged a farmer to let them disinter the body of a cow, which he had buried thirty-six hours before as unfit for human food. Or study the conditions of our coal mines when half-naked women

and girls toiled in them side by side with little tiny boys, and when the "truck" system of wage payment was a phase of slavery. Disraeli interviewed at first hand all these evils, and was startled to find that "infanticide was practised as extensively and legally in England as it was on the banks of the Ganges!" Mothers farmed out their children at threepence a week, to be got rid of in a month or two by hunger and Godfrey's Elixir, or by laudanum and treacle. History of this tragical sort forms the dark foundations of our industrial system; and it should quicken the conscience of to-day, helping to develop that sane conservatism which desires to conserve all good things while clearing away all rust and rot and rubbish.

Such things, we are told, cannot happen now. Let us not boast. The Salvation Army has put into writing a great deal of its welfare work, and so has that busy Society which rescues little children from cruelties. A recent report on housing conditions among Scottish colliers has a hideous bad character far and away too menacing. In this matter the present is the past modified. Welfaring has so much work to do that it strikes awe into those who know its varied scope and its hard nuts. Nearly all the evils of to-day had their worst cause in that hurried improvisation whereby our old country was carried from ancient handicrafts and farming into fevered industrialism.

The war intensified some of them, and bred some new ones also; hence the need of increasing and multiplying sound agencies of a welfaring sort. Increasing and multiplying; for an enormous amount of welfare work was done in pre-war times, as by Chivers at Histon, the Rowntrees near York, Cadbury at

Bournville, and Lever at Port Sunlight. Cadbury's great experiment was the first; it began in 1879, to be followed by Rowntree, and then in 1889 by Lever. These manufacturers, like Disraeli's Trafford and the elder Millbank, are splendidly alive to their duties as upholders of the State. Their big doings are free from that sort of communism which Robert Owen, the first experimenter in Socialism, began to circulate about a couple of years after Waterloo. Owen proposed a scheme for villages, whose inmates were to be employed and educated at the public expense. Everything was to be in common; "Association was to supersede competition; labour was to supersede money," and Owenism was to supersede Christianity. His attacks on Christianity told against his own creed. In his own factory Owen transformed the conditions of labour; opened an infant school, set up co-operative stores with a public kitchen and devoted all profits over 5 per cent to educate and improve his men. Owen's example in communistic reform has been in part copied, in part rejected, by the Lords and Commons. Free education is a phase of communism, for example, and factory legislation has done by compulsive means much that Robert Owen did of his own accord. This tidal advance towards communistic ideals is a thing which welfarers have to study with the utmost vigilance, as it complicates their work by keeping them constantly in touch with rival sects of extremists. As a Conservative I fear it, believing that individual effort and enterprise are in the main, or should be in the main, as essential to trade as they are to music, painting, sculpture, architecture, poetry, letters, and science.

But those who fear an incoming tide have no

reason to think that its rise to high-water mark can be stopped. Their need is to build good groynes to stop the tide from coming too far, from invading snug and great old harbours where the best legacies of our race are noble argosies at anchor. Welfarers can help to build these groynes, with hearty support from those whose confidence they have won; *can* help in this political salvage, and certainly *will* help, if they are well chosen and properly trained.

For two or three generations our country has bred in large numbers a young man with a face almost girlish, a head very shallow behind, and a mind ready to be captured by faddists who adore the prefix "anti" and who wish the whole of mankind to become like themselves. Let us hope that welfarers will not be drawn from these nympholepts of emotion. A race to endure must be robust, and should do the right things not in fussy philanthropics, but in quiet public duties inspired by the pleasure of doing right as a matter of course. Even in its opposition it should be good-tempered. To take an example. At a time when limited liability companies mean a communism of shareholders, as trusts do a communism of autocratic profit-seeking, it is ridiculous to be angry when artisans advocate a rival communism of their own. There is no safety in illogical positions. Ratiocination is the great principle of order in thinking, while the *via media* is a decorated blind alley; yet some welfarers known to me are unable to grasp the importance of these truisms. They are too sectarian to be prudent, truthful, and far-seeing.

For instance, some civilian duties in the war were deplorable, yet they were admired as if they were

desirable as duties. Their bad side, over which historians will meditate, is hidden by a thick varnish of praise. The fine, varied qualities shown by women and girls in munition factories and in other war-time overstrain are virtues to be loved; but, on the other hand, it is horrible that girls and women, who foretell the next generations, should be obliged by the stress of imperative danger to be active in the slaughter of war by helping to make weapons for destroying human lives. This welfare work is in essence woefully tragical, and as much at odds with human nature as it is at variance with the Gospels. Girls were collected from all parts of the United Kingdom, sometimes in towns where vast housing problems already made life uncomfortable, sometimes in improvised places where the first work of welfarers was to build firm paths in mud for the girls to walk across. Sometimes four, five, and even six girls slept in the same bed. Necessary things of every sort had to be prepared, ordered, fixed in a good routine; and I know not which to admire more, the girls' patriotic patience and good temper, or the gifts for organisation shown by many welfare supervisors and chiefs, as by Miss Cottrell at Gretna Green. A man cannot write at all worthily about these matters; he can but hope that some of the women leaders—Miss Cottrell, Miss Hadow, and Miss Yates, for instance, will unite their experience into a collaborated story before their facts appear stale to them and before their impressions of human conduct and character have been blurred by time and by new occupation.

I

Welfare Work among Girls and Women

When large numbers of girls and women were called suddenly from their accustomed routine, many from their homes, many from domestic service, others from school, to be thrown together in munition areas, with the strange fever of war at work in their minds and bodies, and with dark streets to accompany their high, excited spirits after a long day's toil, problems of many sorts were formed at once, and at once needed the best possible solution. To fail in solving them would leave munition-making to become incalculably harmful. The fever of war has not been studied with much frankness; there can be no doubt that it renews and inflames primitive inclinations which usually lie dormant under the restraints of ordinary and ordered life. It draws the sexes much closer together, relaxing the inherited social control which is summed up in the word monogamy. The fever of war is a friend to the wandering sexual relations called free love. So it imposes on society the duty of self-discipline, and this discipline must be of a sort which the people will accept. Welfarers had to form attractive discipline for women, girls, and boys (the men were often restless in strikes). It included comfort, recreation, good food, self-respect, and unfussy leadership that set a good example.

Whether it should have included so much money, while our troops at the Front were selling cheap in pay what is most dear in patriotism, health and life, is doubtful; but leaders of democracy always dependent on wayward votes learn to fear democracy, and

fear begets distrust in weak acts and flattery in loud phrases. Officials told welfarers that the proper way to introduce their aims to employers was to say that welfaring "paid." One welfarer tested this phrase when speaking to a shipbuilder on the Clyde, who said at once with sharp contempt: "If you wish to do good you must put your work on a higher level than that." Officialism was apt also to believe that munition-makers, both male and female, when called on to make an additional spurt, would be nerved by hearing talk about their pay for overtime. Women and girls needed a different appeal, whatever many men may have liked. They wished to be told that their extra strain was necessary to our troops in the field. Some of the female labour came from the roughest strata in our society, yet its patriotism had a strong heart and a good circulation.

I am told that in woman's part in the war, among the munition-workers, there was a fall, not a rise, in the illegitimate birth-rate: surely a notable fact if it is confirmed by final statistics. Cases fit for newspaper headlines and public gossip were given so much publicity that often they were accepted as correct generalisations. As a rule the welfare supervisors found that their sympathy and tact and care had the desired results, aided alike by employers and the trade unions.[1] That so many difficult problems should have been solved in the midst of overstrain and rapid improvisation and the fever of war is to my mind the most admirable fact in our modern social history.

Some bad results were mingled with the good, of

[1] Trade union discontent showed itself when female labour became useful in skilled labour, but against welfare work there was only a little opposition here and there.

course. Munitioneering bred among vast numbers of girls a distaste for domestic service, affecting the middle classes in a way very harmful to home life; and Father Bernard Vaughan warns the nation that "young women have worked themselves to the bone doing war service, and are no longer fit to become mothers"; also that many "have been driving motor-cars and do not want to trundle a baby-cart in the slums." These statements are true, but true in a limited way. The young women who worked themselves to the bone were those least fitted by a life of struggle to bear overstrain; the more wiry girls, previously trained either by hard work or by accustomed hardships, found very often that their physical strength was greatly improved by regular baths, good food, exercise, and comfortable recreation. Many enjoyed plenty of good food for the first time in their lives; and for the first time also had the feeling of true citizenship brought into their day's routine by unfussy order and quiet sympathy. An English lady, on her return home after a long absence abroad, was asked what struck her most in our country's war aspects. She answered at once, the improved physique of the industrial-class girls to be seen after work in the streets. This statement also is true, true in a limited way; and our views must be well balanced.

Then as regards the skill shown by girls in munition factories; to my mind far too much has been said about it, as if girlhood and womanhood had worked a miracle by showing once more that female hands are adaptive, imitative, deft, and swift. It is considerably easier to set a machine to turn a copper band for a 9·2″ high-explosive shell, than to do

such skilled handicraft as women used to do with needles and with primitive spindles. To assemble fuses or to cool shell-forgings is easier than to cook a dinner or to rear a child. To drill a safety-pin hole in a fuse by using a multiple-spindle drilling machine is not more difficult than to mend one of those stockings through which boys wear their heels and toes, with much help from third-rate boots. To help in the making of optical instruments is work of a higher sort, but to draw a hand is equally difficult. A new chivalry came into vogue with the girl graduate and the suffragette. Women began to worship their own sex and to believe that their enterprise was always new, original, and wonderful. This whim has been as foolish as the dogmatism of those male aphorists who begin their curt sentences with the word "Woman," as if women were apart from human nature and had all precisely the same temperament and character.

It is the human aspects of the girl munition-worker, not the use of machines by female hands, that is best worth studying as war history. Among other things we learnt that a vast amount of humbug had been talked by trade unions about skilled labour and its difficulties. If women had the same physical strength as men, they could employ all the machines that men attend and use, and be every bit as effective. A common failing of women workers is that they are over-apt to put an excess of fervour into their apprenticeship, staling their interest and their energy. Hence their endurance during the war is a proof of patriotic self-control.

Another defect is a lack of feeling for accuracy, and above all, that minute accuracy which is essential

in mechanical toil. There is something in most women's minds that rebels against scrupulous truth in descriptions, and in the repetition of hearsay evidence. This something may be the eternal child in mankind, for children have the same inborn defect. At first men alone were admitted as students into the advanced classes, and Miss L. K. Yates writes as follows about the girl recruits in elementary practice :

> The chief battle of the Training Centre with regard to the instruction of women was then, and still remains, the implanting of a feeling for exactitude in persons accustomed to measure ribbon or lace within a margin of a quarter of a yard or so, or to prepare food by a guess-work mixture of ingredients. I remember, at the beginning of a course of training for women, how an instructor at a large metropolitan centre remarked that "ninety-nine per cent of the new students do not know what accuracy means," and he detailed how difficult it was to instil into their minds "that quintessence of their work." Scientific methods of tuition, helped no doubt by women's proverbial patience—[which, by the way, has an energetic foe in modernity]—have enabled the lesson to be learned after a few weeks' intensive training. The courses last but six to eight weeks, and at the conclusion of the carefully graduated tasks, it is not too much to say that the success of the woman has been, in an overwhelming number of cases, surprising to teachers and pupils.

Why surprising ? The feminine deftness of hand is hereditary, and every one who tries can measure correctly with proper instruments. What good can be done by speaking of women workers as though they were infant prodigies ? To demand minute accuracy for known uses will ever be welfare work, but to be surprised by its attainment is enervating flattery. Let accuracy be looked on as a common-

place need, like reading, bathing, walking, and eating. Then we shall not be told by female journalists how "smiling girls," busy as novices, are successful in engineering work which would give to their faces an expression of unsmiling concentration. The new chivalry blunders in this way, because at present women's attitude towards women's industrial work is too much like a hen's concern over a brood of ducklings. But this mood will pass. In a few years the new chivalry will have had its fling, and girl industrialists will be accepted as easily as girl art students have been. New Training Centres are being opened, and the proportion of female to male students hitherto trained in all the processes has been roughly as two to one. There would be something threatening in this proportion but for the great excess of women in our population. But is it not odd that girls should wish to bind their lives to that mechanical drudging which, by its subdivision and its boring monotony, robs men of their craft pride and makes discontent endemic? To make a social problem more difficult is not an act to put happiness into forethought.

During the war, too, I regret to say, girls found that industrialism is a phase of war with casualties of its own. One lost the first finger and thumb of her left hand through the jambing of a piece of metal in a press; several were killed and many injured by a bad accident in an explosives factory; and many other examples could be given. In a big Blue Book—a graveyard of facts—on Industrial Health and Efficiency, I find two sections on Injuries and Accidents. Injuries to the eye were frequent, produced sometimes by exposure to intense heat,

sometimes by eye-strain in ill-lighted places, and often by flying particles of metal, as in grinding and similar jobs. Good lighting and goggles were preventives. The Report adds, in the jargon used by officials, that "a grave amount of disablement is caused . . . by fractures, open wounds, and injured limbs; but probably an even larger amount of interruption to work is caused by slighter injuries, such as scratches and burns, which may, however, become serious if neglected. . . . However effective may be the methods of prevention adopted, some accidents will occur. It is accordingly important that in each shop there should be one or two workers trained to render first-aid in case of accidents. . . . Though in many factories good provision has been made for the treatment of accidents, great improvements should result from the recent Home Office Order requiring employers in certain industries to provide and maintain (*a*) first-aid posts or local dressing-stations for every 150 workers; and (*b*) an ambulance-room or central dressing-station wherever the total number of employees is 500 or more. The room is to be in charge of a nurse or other person trained in first-aid work. Records of all cases treated are to be kept."

"Sometimes," says Miss Yates, "incidents of women's courage in the works have been reported in the press as matters of surprise." Yet the courage of women is a staring truism in all history, and above all in primitive history. If mothers had not been indomitably brave, how could mankind have passed through a tragical evolution? Women are certainly as brave as men, only their courage is more limited by circumstances, for courage in most persons is limited by conditions. It needs experience and the

custom that experience breeds. Napoleon was very brave in many ways, but he was as afraid of cats as many women are of rats and mice. He never tried to overcome this temperamental weakness. That girls adapted themselves with ease to the risks and dangers in munitions factories proves that they could get used to other perils also, as in seafaring, if the need came on them in a national crisis.

To my mind the clubbable temper fostered by women's work in the war is far and away more notable than their adaptable courage, for clubbableness has not been a common virtue among women in any type of society. The tendency of ordered life has been to separate women by a very subdivided party spirit nourished by fashions and castes and habits, as well as by rival physical qualities. After 1914 the welfare influence of clubbableness had a good innings, thanks in part to the emotion of patriotism in the workshops, and in part to admirable rest-rooms, canteens, hostels, and amusements, which appeared after the first over-thronged overstrain, when the Factory Acts were temporarily set aside and women toiled from twelve to fourteen hours, through all the days of a week, and through public holidays also. A young nurse of the medical staff engaged on first-aid affairs within the munitions factories, toiled through shifts of twenty-four hours at a stretch, for a fortnight, while her colleagues were absent. Over this health-destroying bravery I see no reason to rejoice; it reminds us how in every need of foresight our country was tragically unprepared. When I am told that in one training workshop, where girls were busy on the making of small parts for aero-engines, there were cooks, housemaids, dressmakers, and so forth, I ask myself

why pre-war politicians keep their fronts of brass and offer once more to carry the political milk-cans from door to door of the electorate. Nor yet have they explained why they had not even an adequate reserve of rifles in 1914; and apparently they feel no shame of self-reproach when they admit that the results of their past negligence could not have been cleared away without infinite self-sacrifice from women. "We can hardly believe our eyes," said a shipyard foreman, "when we see the heavy stuff brought to and from the shops in motor-lorries driven by girls. Before the war it was all carried by horses with men. The girls do the job all right, though, and the only thing they ever complain about is that their toes get cold." A medal should be given to all surviving members of the pre-war Parliament, bearing on one side the figure of a munitionette, and on the other a few words: "Being unprepared after fifty years of warning, we enlisted girls as well as boys, women as well as men." A medal of this candour would help greatly in the welfare work that historical truthfulness has to do well.

At a moment in the war when women's efforts were still unordered—when, as Miss Yates says, "the shameful conditions to which factory children were subjected at the period of the Industrial Revolution seemed about to return"—a statesman said: "The workers of to-day are the mothers of to-morrow. In a war of workshops the women of Britain were needed to save Britain; it was for Britain to protect them." Obviously; but to state these truisms without any reference to the unpardonable blundering of pre-war times was to show a lack of penitence which historians will neither forget nor forgive. Do

politicians ever intend to regret their past and to add penitence to our national welfare work ?

First-aid attention in workshops, from December 1, 1917, became compulsory in foundries, blast furnaces, iron-mills, copper-mills, metal works, and where T.N.T. was manufactured. Works doctors were supervised by medical officers of the Welfare and Health Department, who guarded also the workers employed in the making of lethal gases. As for rest-rooms and cloak-rooms, they became of great use to the women and girls. The cloak-rooms had cupboards in which hot pipes dried wet boots and clothes ; every girl had her own locker with lock and key ; and basins were supplied with hot and cold water. "In T.N.T. workshops," says Miss Yates, "compulsory washing facilities were even more elaborate. Bath-rooms were available, as well as a generous supply of towels ; and face ointment, or powder, was supplied as a preventive to any ill-effects from handling explosives."

Women police were very useful in the factories, checking the entry of girls, examining passports, searching for matches, cigarettes, and alcohol ; dealing with complaints, helping magistrates at police courts, and aiding in other ways the general discipline and supervision. "As many of the works were erected in lonely places," says Miss Yates, "and as the shifts worked by night as well as by day, it can easily be imagined what a safeguard to the young employee was the presence of these female guardians of the peace. . . . In such ways, welfare work has taken root in the factories of Britain, and in the words of Mr. Lloyd George, 'It is a strange irony, but no small compensation, that the making of weapons of destruction should afford the occasion

to humanise industry. Yet such is the case.' " And one reason is worth italics. Where women's work was concerned, different offices of State managed somehow to put aside their rivalries and to pull together for the common good. Dr. Collis and other welfare leaders must have been ideal diplomats: surely a point worth noting, as energy is often a bad diplomatist, ruffling where it ought to soothe.

Recreation is true diplomacy, and it was aided very much by that fund of money given to the munition-makers by the Maharajah of Gwalior. Grants from this fund bought pianos for canteens and recreation rooms; hence dancing, songs, and music to accompany physical drill. Sometimes there was a dancing mistress, and sometimes outdoor games were taught, the instructors' fees being paid either by employers or out of the Maharajah's fund, as happened now and then. Some engineering shops at Sheffield produced plays, and a firm near Birmingham had a kinema, an orchestra, and a dancing-room. The Y.W.C.A. and other bodies were indefatigable, providing amusements of many sorts, concerts, lectures, dramatic entertainments, and opening recreation clubs —progress which came to remain. Grants from excess profits were given by the Treasury to controlled establishments, and to the management of national factories, for the purpose of stimulating a belief in healthful recreation.

The care given to motherhood among the munitionettes is another requisite to be remembered. It was uniformly governed by watchful care and tact. The old Puritan scarlet letter did not show its inhumanity when a baby did not possess a married mother. Miss Yates has written some admirable

pages on the factory nursery, and I choose for quotation a model nursery near Woolwich.

It is a long, low building of bungalow type, surrounded by a small garden. The main room, the babies' parlour, is a long apartment enclosed on two sides by a verandah, and on the third by a wide passage well ventilated at each end. The room itself is full of light and air, there is plenty of play room, and no awkward corners to inflict bruises unawares. A lengthy crawl brings a baby-boarder into the sunshine of the verandah and the safe seclusion of its play-pens, and a longer crawl . . . is rewarded by entrance into the surrounding garden, where a delectable sand-pit is a permanent feature. . . . Mattresses occupy part of the floor space of the nursery, and at night-time are developed into full-fledged beds. At one end of the room are cupboards let into the walls; at the other, furniture fashioned for the needs of each "two feet nothing." There, instead of being perched on a high chair to feed with giants from an elevated table-land, the infant visitor sits on a miniature arm-chair at a table brought to the level of childhood. The low tables are, in fact, kidney-shaped and hollowed on the inside, so that a nurse, or attendant, seated in the centre, may feed half a dozen children in turn. . . . Another room in this delightful babies' house is devoted to infants: a brigade in cots, of which the advance guard, during fine weather, invade the verandah. The daintiness of the room with its blue curtains and cot-hangings and the chubby satisfaction of the cot-dwellers must be a constant inspiration to the visiting working mothers. Spotless kitchens for the preparation of the children's meals are situated in the rear of the nurseries; there is also an isolation room where suspect infectious cases are detained, and a laundry with an indefatigable laundress. The bathing room, fitted with modern appliances, is in many respects excellent. The whole establishment is warmed by a central-heating installation, the radiators being well protected with guards.

A type of society that breeds slums and working

mothers in vast numbers certainly needs nurseries of this sort, if the stamina of our race, now and in the future, is to be improved; but persons who think must admit frankly that artificial restoratives have perils of their own. Ideal nurseries are well-managed homes. Others, however good and essential, are like hospitals and public charities — symptoms of disease in society. Was it not Dean Swift who believed that all children should be taken from their parents — to be brought up properly? This communism in baby-culture would be sure to harm greatly the instinct of parentage, which even the smallest birds and the fiercest wild beasts usually obey. The delicate varied beauty of many birds' nests is honour paid by trifles of brain to parentage; and surely women should be on their guard against anything which may weaken in society the responsibilities of mothers and fathers. Already the working classes have been taught that the education of their children is a duty for the State to fulfil; and now many trade unionists refuse to pay income tax. For things in human life hang together, and when the State impairs one sense of responsibility in women and men, another is certain to be affected by ricochet; then general citizenship is impaired.

Let us remember then that the most horrible war in all civilised history came (*a*) after a century of industrialism, and (*b*) after the greater part of Europe had spent enormous sums of money for a long time on compulsory free education. If welfare workers fail to weigh and measure these matters with recurrent care, the presence of girls and mothers in the strife of industry cannot be a help to citizenship. Indeed, what the world seems to need most of all is a much

smaller population, with a more equal distribution of the sexes. Women in our country are far too numerous. Their surplusage is the cause of infinite discontent, and is thus a menace to the common good. What problem in welfare work is more urgent than this, the producer of many others ?

When men become the rare sex and women the superabundant sex with millions of votes, human nature in society cannot be normal. Its balance has gone. Far too many of its thwarted passions wear petticoats. Add this matter both to the mothers who toil for industrialism, and to the crowd emotion that party spirit in political elections lets loose. Statistics do not say how many married women have to labour away from their homes ; but we know that the excess of women in our national life equals nearly one-fourth of Greater London's population. When is this grave matter to be studied frankly in all its bearings by welfarers ? A far-scattered Empire has so much sea between her parts that her unity is a very delicate thing which may easily be broken by abnormal conditions in the mother country. Indeed, empires have failed either because the pride of empire demoralised the social character, as in ancient Rome, or because their social character became too self-willed to think as an Imperial commonwealth. These dangers are always active together when conquests are collected into empires, and our chief danger is the pride of unrest in the British Isles. Will this danger increase now that the superabundant sex has millions of votes with which to intensify the fever of party politics ? Let no welfare worker neglect to study this question.

II

Welfare Work and the Trade Unions

There are many persons who believe that trade unionism is opposed to welfare associations and enterprise. If this belief were true it would not be surprising, because the creed of supply and demand, with infinite fudge about "cheapness" and the "cash nexus," enforced upon labour through a century a hard bargaining by which the amenities of working hours were chilled and embittered. During the railway strike the Prime Minister said that railwaymen in pre-war times were very much underpaid; and when workmen are sacrificed to shareholders, or to Trusts, why should they have confidence in welfare work? Is it not natural for them to say, "What does the Board meeting expect to get out of this? What's the game now?" Before the war this question, with its cynical suspicion, was asked frequently. When a country passes from a system of small employers who know their men personally to huge Trusts, Corporations, and Limited Liability Companies, the change is in the nature of conquest, and to keep conquest from becoming autocratic is very difficult. To-day welfare workers are as neutrals and peacemakers between two vast armies, organised Labour on one side, organised Trusts and Companies on the other; so the national problem is how to restrain these armies from acting and reacting constantly against each other, and thus against the community as a whole.

It is a problem full of ethical difficulties and anomalies. Thus we approve in mercantile enter-

prise the very aggression which Prussia desired to use for her own ends in European politics. If a great shop financed by shareholders devours a dozen little shops in its neighbourhood, and attracts business from many small shops far away from it, we speak with admiration of its push and go, as though small employers and their well-being have no claim on our social and ethical sympathies. Reason suggests that minor trades are to each town and country what minor nations are to the civilised world—the Belgiums, Hollands, Denmarks, Switzerlands of each community. They cannot be less than this in the high ethics of society; and if we must needs run counter to their rights because trade has become so international, and so perilously competitive, that huge organisations are requisite, let us be candid and talk no cant. The doctrine of necessity governs us, however much we may talk about high thoughts and right feelings. To swallow up small employers cannot be more moral than to swallow up little nations. There is a difference here in scale, but not in principle. To be useful to its shareholders a busy big company must go ahead as a sort of aggressive empire in competitive business, fostering the very temper that idealists want to dismiss from the world by means of that immense company, with limited liabilities, named the League of Nations.

Welfarers have far more than enough to keep their minds alert and their bodies lean with activity. But they value what Disraeli regarded as the sovereign truism in human affairs; namely, that rationalism has not been, and never will be, the main factor in mankind's progress. Any attempt to reconstruct society on a purely rational basis, on a basis of material

motives and calculations, is certain to fail, especially in an ancient and a densely peopled kingdom; because the motive-power in humanity is passion, ardent faith with ambition, not cold, bleak, balancing reason. "Man is truly great only when he acts from the passions, never irresistible but when he appeals to the imagination. . . . We are not indebted to the reason of man for any of the great achievements which are the landmarks of human action and human progress. It was not reason that besieged Troy. It was not reason that sent forth the Saracen from the desert to conquer the world, that inspired the Crusader, that instituted the monastic orders. It was not reason that created the French Revolution." And how much reason do we find in the production of widespread need for welfare work—a social crusading spirit lit by faith and appealing to the imagination?

Both employers and the trade unions have felt this appeal, and welfare workers now are in the position of physicians and the clergy, dependent on their own worth, with open free fields before them. As they cannot be too able, they should be enlisted from all classes, and their pay must be enough to attract worthy ambitions and uncommon abilities. Also it is clear that they should be paid, not by employers, not by trade unions, not by private charities, but by the State, subject to conditions approved by trade unions and employers. That is to say, their choice should be approved by both "sides"; but when once a welfare supervisor has been chosen, his position of scrupulous neutrality needs that just freedom which payment by the State would give both to him and to his unbiassed service to the common good. If he were paid by a trade union or by a trad-

ing company he is obliged by honour to give especial attention to his paymaster's interests; he cannot be strictly neutral as the genius of his duties requires. I should like to see a Congress at which the six parties concerned in the results of welfaring would be fully represented: the six parties being the Government, the Employers, the Trade Unions, the Electorate, the Churches, and the Welfare Supervisors and Leaders.

In April 1918 the Woolwich District Trades and Labour Council, with the Woolwich Labour Party, issued a pamphlet on Welfare Supervision—a very interesting pamphlet, to be bought for threepence at 3 New Road, Woolwich. It is in all respects a frank survey to be bought and studied. In its General Criticisms and Suggestions its compilers say:

Many questions have arisen as to the need for welfare supervision in our industrial life, its functions in relation to those of trade unions, and its overlapping with the duties of other Government Departments and of public authorities. It is argued that a great extension of the Factory Acts, with a large and efficient staff of Factory Inspectors, would do away entirely with the need of welfare supervision in our factories. Such might be the case; but, on the other hand, a true welfare worker, in close personal touch with the other workers of the factory, supplies a link which the ordinary Factory Inspector does not and cannot supply. The danger of the welfare worker lies in the fact that such a worker is now the servant of the employer, and, as such, is a part of the management in the employer's interest. A welfare worker of the necessary training and experience, who is appointed by the workers, and whose position is protected and defined by the law, might be the most satisfactory person to look after the real interests of those workers. . . . In Woolwich, as elsewhere, many of the duties undertaken by Welfare Departments have been necessary owing to the laxity of public

authorities, and also to the unnatural conditions, such as long hours, etc., under which the workers have to live. . . .

The statement of the duties of welfare supervision contained in Memorandum 2 of the Health of Munition Workers Committee may be taken as a working basis for the purposes of welfare supervision. The Memorandum states that "the duties here outlined are chiefly concerned with matters of health and individual welfare which are of immediate urgency to-day." Modification of or addition to these duties will doubtless be brought about by increasing experience, and by the changes which are likely to arise in the industrial system after the war; but we submit that the following conditions are essential to any scheme of welfare supervision that is to win the full confidence and support of the workers [*i.e.* the trade unions]:

1. Welfare supervision must aim primarily at promoting the welfare of the workers, and not at increasing the workers' output.

2. In the interest of welfare supervision and of the workers, duties which conflict with welfare supervision must not be included in the work of welfare supervisors.

3. Welfare schemes and supervisors must be under a democratic system of control in which the workers shall have equal participation with the employers.

4. The established field of operations of trade unions and their officials must be clearly and loyally recognised by welfare schemes and supervisors.

5. Welfare supervisors should be drawn, as far as possible, from among the workers.

6. Welfare supervisors should not be appointed without preliminary training or experience, such training to include a knowledge of trade union aims and methods.

7. The remuneration and hours of all assistants in welfare supervision (*e.g.* canteen workers) must be of a trade union standard.

8. If Government control of welfare supervision is maintained after the war, such control must be transferred from the Ministry of Munitions to the Ministry of Labour.

We submit further:

9. That there should be the maximum of efficient co-operation among local welfare schemes, especially with regard to small factories.

10. That there should be the maximum of efficient co-operation between local welfare schemes and the Municipality, especially with regard to health, housing, transit, and recreation.

11. That as welfare supervision will probably become a permanent and an extending element of the industrial system, there should be held, in each industrial centre, one or more conferences, convened by the Trades Council, or, where there is also a local Labour Party, by both bodies jointly, for the purpose of considering the aims, scope, and methods of welfare supervision; and that such local conferences should be followed by a joint Conference of the Trades Union Congress and the National Labour Party.

A Congress to represent the whole community would be much better because unsectarian. The main appeal of welfaring centres around women, girls, and boys, and hence the community as a whole has to respond. The welfare of boys in industry is a subject by itself, and my readers should write to the Boys' Welfare Association, 33 Tothill Street, Westminster, London, S.W. 1, a body directed by the Rev. Robert R. Hyde. What the Boy Scouts movement has been out of doors, this excellent Association aims at being to lads in industry. Its progress has been rapid, it has a Journal addressed mainly to its supervisors, and I am happy to quote some good things written about its necessary service by Mr. W. L. Hichens:

One of the great problems of modern industry is how to humanise big organisations, how to secure to them a really

corporate existence, how to make them something more than mere wealth-producing machines. And if any one is in doubt how to set about it he cannot do better than start at the bottom of the industrial ladder with the boys employed by his firm, and secure to them an all-round training which will fit them to become not merely a part of the corporate life of the firm but also citizens of the British Commonwealth. For this is the real meaning of the phrase " welfare work," which is too often used in the narrower sense of physical and moral well-being, so that the " boys' welfare movement," which is one of the most remarkable developments of the war, is apt to be regarded merely as a philanthropic or missionary enterprise. It may perhaps more accurately be styled " the movement for the training of boys in industry," for it aims not merely at the physical training of the boys through games and sports, not merely at the development of their moral natures, but also at the improvement of their education, both general and technical —in a word, it aims at turning out industrial citizens.

It has come to be recognised that the responsibility of a firm towards its apprentices is not confined to teaching them a trade or mere manual dexterity, but that it must cover a wider range, and give recognition to the fact that something beyond the " cash nexus " is needed to secure the corporate unity upon which industrial success depends. The all-round training, therefore, of apprentices—so designed as to promote their welfare in the truest sense—must be recognised by all as an important factor in industrial policy, and for this reason the work which is being carried out by the Boys' Welfare Association under the best auspices is deserving of the widest support.

INDEX

THE END

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